Editorial

This issue of Phelsuma contains our usual mixture of papers on taxonomy, captive breeding, ecology and conservation. This issue differs from our previous 17 issues in that Phelsuma is now exclusively an on-line open-access journal. This continues a process started last year with the open-access special issue on climate change. This special issue raised considerable interest but few manuscripts have been forthcoming. This issue will remain open for publication of papers on climate change in the Western Indian Ocean. A second paper in the issue was published this year (concerning species extinctions in Seychelles that can be attributed primarily to climate change) and can be accessed at http://islandbiodiversity.com/phelsuma17A.htm

We have changed to an exclusively electronic format from the earlier print version for two reasons. Firstly for economic reasons; the cost of printing continues to increase while subscribers find it increasingly difficult to support subscriber journals. Secondly, having Phelsuma as an open-access journal meets our aim of providing a forum for the dissemination of good quality scientific information to support research and conservation in the Western Indian Ocean. NPTS recognises the great importance of the free exchange of information and for this reason we were among the original signatories to the Conservation Commons in 2004. Our commitment to information sharing is also reflected in our decision to publish on-line all annual reports of our projects. The following links provide access to our reports and publications:

Phelsuma: http://islandbiodiversity.com/phelsuma.htm
Annual Scientific Reports: http://islandbiodiversity.com/reports.htm
Sheath-tailed bat project reports: http://islandbiodiversity.com/2009bat.htm

Changing Phelsuma to an open-access model reflects the significant global changes that are occurring at present. Scientific publication is rapidly moving towards on-line publication, dramatically expanding circulations and the speed of publication. This should be of enormous benefit to researchers and conservationists but does mean that some regions (including parts of the Western Indian Ocean) will be seriously hampered by inferior internet connections. We are aware of this problem and endeavour to make our publications as easy to download as possible. Research and conservation in Seychelles will in future depend on improved communications infrastructure. This is even more urgent for Madagascar and the Comoros.

Conservationists also need to take into account economic changes with the ongoing global recession and remaining risk of depression. The significance of the economic situation varies markedly in each of the countries in the Western Indian Ocean due to their different situations. Madagascar and the Comoros are hardly changed by the current situation, needing enormous levels of economic development. Mauritius has already had to adjust to economic change after the decline of the sugar industry and

conservation has already had to diversify its sources of support. Réunion retains its peculiar situation as a region of France. In Seychelles all conservation NGOs rely to a very large extent on tourism for their funding and in the current economic climate this is not tenable. Conservation urgently needs different sources of support. This pressure is occuring at a time of great unpredictability caused by climate change. Although economics have led to attention drifting away from this, climate change remains the greatest threat to all species and ecosystems. All NPTS projects take this into account as the first factor that must be considered. We hope that making our information as widely and easily available as possible will help in the urgent search for solutions.

J. Gerlach
Editor

Chairman's Report

In the first few months of the year covered by this report, we were quite buoyant. The financial crisis out in the wider world and the related changes in Seychelles seemed not to have had a major impact on tourism upon which we are all so dependent. We were able to continue financing our various projects through donations and sales of fundraising items in return for informative talks to the steady stream of visitors from Labriz – the hotel on Silhouette.

The second half of the year was unexpectedly complicated by some family health problems which necessitated extended periods of absence from Seychelles. However, we were able to keep all projects progressing with the help of Justin, Sussex University, Roc and Gilbert from IDC and Sandra from Labriz. Mo van der Merwe held the fort for us on Mahé and Vinesh Gupta, the general manager of Labriz, was as always, very supportive.

While most of our monitoring is concentrated on the fauna and flora, this year we have established a number of new weather stations in order to combine climate change data with population data, setting a baseline from which we will be able to determine the impact on biodiversity. Monitoring these changes has become much more important in view of the growing level of scepticism about climate change that was given disproportionate publicity at the end of 2009.

Data collected during the Indian Ocean Biodiversity Assessment 2000-2005 continues to be collated and published in the form of species monographs. This year has seen the publication of two new monographs:

The Coleoptera of the Seychelles Islands. Pensoft. Edited by Justin Gerlach

The Arachnida and Myriapoda of the Seychelles Islands. Siri Scientific Press. Edited by Justin Gerlach and Yuri Marusik

This brings to seven the number of monographs published, with a major work on the spiders in press.

We would like to thank the following individuals and organisations for their support:

Islands Development Company	Accommodation and secondment of one fieldworker for the tortoise project
Labriz Silhouette	Logistical and project support
Mohamed bin Zayed Conservation Fund	Project funding
Pool & Patel	Honorary Auditors

The annual Sussex University field course participants were once again a great help with vegetation management and monitoring in March.

Scientific and Other Visitors
Prof. Savel Daniel from Stellenbosch University spent time on Silhouette in May, carrying out research on the freshwater crabs. Dr. Bruno Santerre visited in November and December to survey the habitat of Mont Dauban.

Overseas Visits and Meetings
In September Justin Gerlach attended a meeting of the IUCN Species Survival Commission's Invertebrate Conservation Committee. This discussed ways of increasing the number of invertebrate species assessed for the Red List; as Terrestrial and Freswhater Invertebrate Red Listing Authroity Chair Justin will be closely involved in this process in the future.

Seychelles Giant Tortoise Conservation Project
It is now thirteen years since we embarked on this project with the aim of re-establishing viable populations of the granite island giant tortoises on Silhouette. In 2006, we released five adult Dipsochelys arnoldi onto the coastal plateau of Grande Barbe. This transfer was undertaken with the agreement of the hotel company holding the lease on the land. These tortoises have been monitored over the last three years and their impact on the vegetation observed. They appear not to have bred, but this is a likely consequence of so few individuals in such a large area.
Permission to proceed with the first release of juvenile tortoises was requested in March but had not been granted at the time of writing this report, four months later. The proposal we submitted was to release 30 Dipsochelys arnoldi juveniles weighing between 10 and 20 kilos into one of two possible sites. The first choice would be Baie Cipailles, which lies at the north-east end of La Passe and just beyond the hotel. This site would give us easy access for monitoring the progress of this first group of juveniles. The second site is Grande Barbe with its extensive plateau and less precipitous access to the forest above. Grande Barbe would provide suitable habitat for many tortoises but for the first release of juveniles it would present us with less data as monitoring would be less frequent.
The captive breeding of these two groups of giant tortoises has progressed very well. The decision to release the adult D. arnoldi group was taken when they had produced 135 young, which we deemed to be a suitable number to sustain a wild population on Silhouette. The D. hololissa have been slower to breed, mainly because we have only one fertile female and because her fertility dropped to almost zero during the building operations on the property adjacent to the enclosures. In 2009, with the return of peach and quiet, she had her most productive year and we now have 37 juveniles.

Seychelles Terrapin Conservation Project
Most of our attention this year was concentrated on collaboration with the FFEM project to reintroduce terrapins to North Island. All the Pelusios subniger terrapins were kept in quarantine in our enclosures on Silhouette and were fed on uncontaminated commercial terrapin food. They were transported in two batches to North Island and were initially released into a fenced marsh. The fence was later removed and the terrapins given

access to the other marsh area.
On Silhouette the last of the captive bred and adult P. subniger were released at Grande Barbe. The Pelusios castanoides did not breed again this year. The number of adults and captive bred juveniles was reduced when a planned release into suitable habitat at the hotel was undertaken.

Silhouette Conservation Project
A monitoring programme and further surveys were maintained this year. Funding from Mohamed bin Zayed Conservation Fund has enabled us to increase the amount of weather data we collect on Silhouette and to compare this data with flora and fauna population data. This is intended to pinpoint any problems that arise as a consequence of climate change.
The anticipated declaration of the Silhouette Island National Park to coincide with World Biodiversity Day on 22nd May did not materialise. This was a result of a high level international meeting to discuss the Somali piracy problem. The National Park was finally declared on 7th August.

Seychelles Sheath-Tailed Bat Project
Monitoring of the La Passe roost continued throughout the year. This entails monitoring activity via the CCTV link, accurate visual counts and constant roost temperature data gathering. In December we recorded the highest population count of 40 bats since the start of this project.

Progress in the forest restoration area adjacent to the bat roost has been somewhat erratic this year because of our time away from Silhouette. During each visit we have had assistance from the Labriz gardeners to maintain the restored area but have been unable to extend the restored area. We have reached a point where it is necessary to fell a number of coconut palms in places where they are covering the forest floor with sprouting nuts and saplings. As coconuts are still a protected species, despite their invasive nature within conservation areas, it is necessary to obtain permission to fell them from the Forestry Division. Unfortunately despite our written request and subsequent phone calls we have had no response to this request.

In conclusion, I wish to thank all those people mentioned earlier in this report for their help and support this year.

R. Gerlach
Chairman

2009 Publications

[Ami = Amirantes; Ald = Aldabra; Sey = Seychelles]

Anderson, RC. Do dragonflies migrate across the western Indian Ocean? *Journal of Tropical Ecology* 25: 347-358

Aptroot, A. A revision of the lichen genus *Stirtonia*. *Lichenologist* 41: 615-625

Benda, P & Vallo, P. Taxonomic revision of the genus *Triaenops* (Chiroptera: Hipposideridae) with description of a new species from Southern Arabia and definitions of a new genus and tribe. *Folia Zoologica* 58(1): 45

Bonato, L & Minelli, A. Diversity in the maxillipede dentition of *Mecistocephalus* centipedes (Chilopoda, Mecistocephalidae), with the description of a new species with unusually elongate denticles. *Contributions to Zoology* 78(3): 85-97

Brook, S, Grant, A & Bell, D. Can land crabs be used as a rapid ecosystem evaluation tool? A test using distribution and abundance of several genera from the Seychelles. *Acta Oecologica* 35(5): 711-719

Brouwer, L, Groothuis, TGG, Vedder, O, Eikenaar, C, Richardson, DS & Komdeur, J. Do Primary Males Physiologically Suppress Subordinate Males? An Experiment in a Cooperatively Breeding Passerine. *Ethology* 115(6): 576-587

Catry, T, Ramos, JA, Le Corre, M & Phillips, RA. Movements, at-sea distribution and behaviour of a tropical pelagic seabird: the wedge-tailed shearwater in the western Indian Ocean. *Marine Ecology - Progress Series* 391: 231-242

Catry, T, Ramos, JA, Monticelli, D, Bowler, J, Jupiter, T & Le Corre, M. Demography and conservation of the White-tailed Tropicbird *Phaethon lepturus* on Aride Island, Western Indian Ocean. *Journal of Ornithology* 150(3): 661-669

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Groombridge, JJ, Dawson, DA, Burke, T, Prys-Jones, R, Brooke, MD & Shah, N. Evaluating the demographic history of the Seychelles kestrel (*Falco araea*): Genetic evidence for recovery from a population bottleneck following minimal conservation management. *Biological Conservation* 142(10): 2250-2257

Halford, AR & Caley, MJ. Towards an understanding of resilience in isolated coral reefs. *Global Change Biology* 15(12): 3031-3045

Holzinger, WE. A novel trophobiosis between ants (Hymenoptera: Formicidae) and a palm-feeding planthopper (Hemiptera: Cixiidae). *African Entomology* 17(1): 115-118

Holzinger, WE. A new endemic genus of Oecleini from Seychelles (Hemiptera:

Fulgoromorpha: Cixiidae). *Zootaxa* 2127: 59-68
Hugel, S. 2009 New Landrevinae from Mascarene islands and little known Landrevinae from Africa and Comoros (Grylloidea: Landrevinae). *Ann. Soc. Entomol. Fr. (n.s.)* **45**: 193-215
Larson, HK. Review of the gobiid fish fenera *Eugnathogobius* and *Pseudogobiopsis* Gobioidei: Gobiidae: Gobionellinae), with descriptions of three new species. *Raffles Bulletin of Zoology* 57(1): 127-181
Latypov, YY. Species composition and distribution of scleractinians on the reefs of the Seychelles Islands. *Russian Journal of Marine Biology* 35(6): 454-462
McClanahan, TR, Graham, NAJ, Wilson, SK, Letourneur, Y & Fisher, R. Effects of fisheries closure size, age, and history of compliance on coral reef fish communities in the western Indian Ocean. *Marine Ecology Progress Series* 396: 99-109
Kueffer, C, Kronauer, L & Edwards, PJ. Wider spectrum of fruit traits in invasive than native floras may increase the vulnerability of oceanic islands to plant invasions. *Oikos* 118(9): 1327-1334
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Malan, G, Hagens, DA & Hagens, QA. Nesting success of White Terns and White-tailed Tropicbirds on Cousine Island, Seychelles. *Ostrich* 80(2): 81-84
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Pemberton, JW & Gilchrist, JS. Foraging Behavior and Diet Preferences of a Released Population of Giant Tortoises in the Seychelles. *Chelonian Conservation and Biology* 8(1): 57-65
Pilato, G & Lisi, O. Tardigrades of the Seychelles Islands, with the description of three new species. *Zootaxa* 2124: 1-20
Pistortus, PA & Taylor, FE. Declining catch rates of reef fish in Aldabra's marine protected area. 5th Western-Indian-Ocean-Marine-Science-Association Symposium (WIOMSA). *Aquatic Conservation Marine and Freshwater Ecosystems* 19: S2-S9
Rakotondrainibe, F & Tronchet, F. Synoptic revision of the genus *Lastreopsis* Ching (Dryopteridaceae) in Madagascar. *Adansonia* 31(1): 7-24
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Senterre, B, Gerlach, J, Mougal, J & Matatiken, D. Old growth mature forest types and their floristic composition along the altitudinal gradient on Silhouette Island (Seychelles) – the telescoping effect on a continental mid-oceanic island. *Phytocoenologia* 39(2): 57-174

Sheldon, FH, Lohman, DJ, Lim, HC, Zou, F, Goodman, SM, Prawiradilaga, DM, Winker, K, Braile, TM & Moyle, RG. Phylogeography of the magpie-robin species complex (Aves: Turdidae: *Copsychus*) reveals a Philippine species, an interesting isolating barrier and unusual dispersal patterns in the Indian Ocean and Southeast Asia. *Journal of Biogeography* 36(6): 1070-1083

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Uhlig, M & Janak, J. Erichsonius (Sectophilonthus) jelineki sp nov., the first representative of the genus from the Seychelles (Coleoptera: Staphylinidae: Staphylininae). *Acta Entomologica Musei Nationalis Pragae* 49(2): 695-710

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The geophilomorph centipedes of the Seychelles (Chilopoda: Geophilomorpha)

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Introduction

All data published so far on the geophilomorphs occurring in the Seychelles are found in three taxonomic and faunistic papers dealing with the whole centipede fauna of the Seychelles, based on the examination of limited series of specimens (tab. I): Brölemann (1896) recorded only two species of *Mecistocephalus* Newport, 1843 and Attems (1900) recorded a species of *Mecistocephalus* and a species of *Thalthybius* Attems, 1900 (now *Ityphilus* Cook, 1899); based on more numerous specimens, Demange (1981) recorded 7 species, including four *Mecistocephalus*, one *Tygarrup* Chamberlin, 1914, one *Nesogeophilus* Verhoeff, 1924 (now *Tuoba* Chamberlin, 1920) and one *Thalthybius*. Demange (1981) also revised all published data, and re-examined the specimens previously studied by Brölemann (1896). With these studies, however, the species composition of the Seychelles geophilomorph fauna remained only partially documented and some taxonomic issues remained unsolved.

Recent sampling within the "Indian Ocean Biodiversity Assessment 2000-2005" project, promoted by the Nature Protection Trust of Seychelles, gave us the possibility to examine a larger series of specimens, from a wider range of islands, and allowed us to obtain a more advanced, although still preliminary, assessment of the geophilomorph fauna of Seychelles.

Methods

We performed a comprehensive analysis of the geophilomorph fauna of the Seychelles through direct examination of newly collected specimens as well as a critical evaluation of the relevant literature. The geographical scope of our analysis comprises all islands under the administration of the Republic of Seychelles.

Table I. Comparative data of the published faunistic accounts on the Geophilomorpha of the Seychelles.

	Brölemann, 1896	Attems, 1900	Demange, 1981	this paper
no. specimens	4	4	54	69
no. localities	3 or 4	1 or 2	14	ca. 20
no. islands	3	1	4	13
no. species	2	2	7	8

A total of 69 specimens, collected from all main islands of Seychelles as well as from some minor islands, was examined comparatively through light microscopy. Specimens were clarified through immersion in lactophenol or ethylene glycol and mounted on temporary slides, following standard procedures (Pereira 2000; Foddai *et al.* 2002). Simplified drawings have been prepared after digital photographs, taken through a Leica DMLB light microscope, at 50-400X. Measurements were taken through a graduate scale mounted on an eyepiece. All specimens are in the collection of the authors, but for the holotype of *Mecistocephalus megalodon* Bonato & Minelli, 2009.

Geophilomorpha of Seychelles

Mecistocephalidae Bollman, 1893
Diagnosis: Body slightly depressed, uniformly wide in its anterior three quarters, the posterior part tapering. Colour pale yellow to red-brown, head and the first few trunk segments usually darker. Antennae slender, gradually attenuated. Cephalic capsule conspicuously depressed, evidently longer than wide, lateral margins convergent backwards. Clypeus and buccae with an anterior areolate part and a posterior part which is virtually non-areolate (plagula/ae). Labrum composed of a mid-piece and two side-pieces; each side-piece divided by a transverse thickened ridge into an anterior and a posterior sclerite (alae). Mandible bearing a series of pectinate lamellae. Maxillae I with coxosternum either divided or not by a mid-longitudinal sulcus; coxal projections and telopodites similar in shape and length, uniarticulate, composed of a sclerotised basis and a hyaline distal part, without additional lobes. Maxillae II with coxosternum areolate in the median part; claw of telopodite usually simple, sometimes reduced to a slender spine or a stout tubercle. Forcipular tergum evidently narrower than the head and the subsequent tergum, forcipular pleura widely visible from above. Forcipular coxosternum only slightly wider than long, the anterior margin almost straight and bearing a pair of tiny tubercles, the lateral margins only slightly convergent backwards; no chitin lines. Forcipules relatively large and elongate, clearly visible from above beyond the lateral margins of the head, usually also in front of the same; article I with a distal tubercle, sometimes also a proximal tubercle; each of the intermediate articles often with a tubercle. Sterna of leg-bearing trunk segments with a mid-longitudinal sulcus; pore areas usually absent. Coxal glands of each coxopleuron opening into many scattered pores. Telopodite of last pair of legs composed of 6 articles, slender, not evidently swollen in the male, longer than the telopodite of preceding legs; claw absent. Gonopods biarticulate in both sexes.
Geographical distribution: mainly subtropical and tropical continental lands and islands from Africa, through southern and eastern Asia, northwards reaching Kuril islands, to Australia and many islands in the Pacific Ocean; also disjunct, limited areas in south-western part of North America, tropical Americas, and central Europe.

Tygarrup Chamberlin, 1914
Tygarrup Chamberlin, 1914: 210.

Brahmaputrus Verhoeff, 1942: 49. (Synonymy by Crabill 1968a: 287).

Diagnosis: Clypeus with an entire plagula, extending along the lateral margins of the clypeus, without a mid-longitudinal areolate stripe. Buccae without spiculum and without setae. Posterior margin of labral side-pieces entire, without notches and without a fringe. Coxosternum of maxillae I with a mid-longitudinal sulcus. Coxosternum of maxillae II undivided; groove from the metameric pore reaching the lateral margin of the coxosternum. Telopodites of maxillae II overreaching those of maxillae I; claw present. Forcipular tergum without a distinct mid-longitudinal sulcus. Forcipular article I with a distal tubercle only, without a proximal tubercle. Sterna of leg-bearing trunk segments with non-furcate mid-longitudinal sulcus; pore areas absent in the female, usually present in the male. Number of leg-bearing segments 43 or 45, invariant within a species.

Geographical distribution: mainly from the Himalayas, through the Indochinese region, to part of the Indonesian archipelago; also a few islands in western Indian ocean (Mauritius and Seychelles), a few islands south of Korean Peninsula and Ryukyu Islands, and the Hawaii Islands.

Tygarrup javanicus Attems, 1929

Tygarrup javanicus Attems, 1929: 152.

Published records for Seychelles: *Tygarrup javanicus*: Demange 1981: 623, 626, 628-9, 640 (description), figs 8-10.

Material examined: 10 specimens. La Digue: Belle Vue, 16-I-1999, 1 ♀. Mahé: Le Niol, 3-VIII-1991, 2 ♀♀. Praslin: Valle de Mai, 19-III-2002, 1 ♀. Silhouette: Anse Mondon Valley, 350 m, VIII-2000, 1 ♀; Gratte Fesse, 3-VIII-1998, 1 ♀; Jardin Marron, 18-I-1999, 2 ♀♀; same, 400 m, 5-VII-2000, 1 sex unknown; La Passe, 12-VII-2001, 1 ♀.

Diagnosis. Body length up to 1.8 cm. Colour pale yellow, with fine dark pigmentation on the dorsal side of the trunk. Cephalic capsule ca. 1.3-1.4 times as long as wide. Antennae ca. 3 times as long as the head width. Antennal apical sensilla ca. 12-15 µm long, with a mid-length flattened circular projection. Ca. 5 pairs of setae along the anterior margin of the clypeal plagula, and a more posterior pair of setae close to the mid-line; no setae on the antero-external corners of the clypeus inside the areolate part. Mandible with ca. 6 pectinate lamellae, the first lamella bearing ca. 5 teeth, an average intermediate lamella bearing ca. 10 teeth. Forcipular article I with a stout distal tubercle; article III with a smaller tubercle; other articles without tubercles. Invariantly 45 leg-bearing segments. Each coxopleuron of the last leg-bearing segment with ca. 15-20 pores, scattered on the ventral and lateral sides, with two larger pores along the lateral margin of the relevant sternum. Gonopods fully developed in females longer than 16 mm. See fig. 1.

General distribution: Indochinese peninsula, Java, Hawaii Islands, and the Seychelles; also recorded from Round Island (Mauritius) (III-2002, 1 specimen, orig. obs.).

Distribution in Seychelles: 8 localities in 4 islands. La Digue: Belle Vue (new). Mahé: La Misère, 438 m (Demange 1981); Le Niol (new). Praslin: Vallée de Mai (Demange 1981; also new). Silhouette: Anse Mondon Valley, 350 m (new); Gratte Fesse (new); Jardin Marron, 400 m (new); La Passe (new).

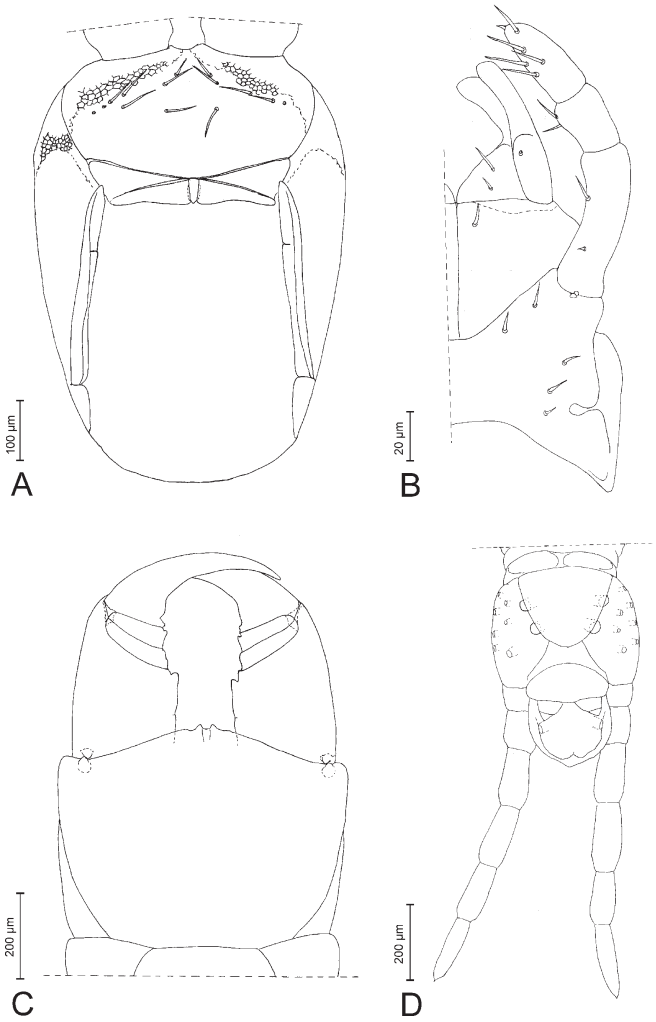

Fig. 1. *Tygarrup javanicus* Attems, 1929 (Praslin, Valle de Mai, 19-III-2002, ♀, 18 mm long): ventral view of selected parts. A, cephalic capsule without maxillae (areolation of clypeus drawn only partially). B, maxillary complex (left half). C, forcipular segment (setae not drawn). D, last leg-bearing segment and posterior tip of the trunk (setae not drawn).

Taxonomic remarks: *T. javanicus* was originally described by Attems (1929) upon specimens from Java. The species was subsequently recorded, redescribed and illustrated again (e.g., Attems 1938; Titova 1983; Lewis & Rundle 1988; Bonato *et al.* 2004).

Our attribution of the Seychelles populations to *T. javanicus* is consistent with the opinion of Demange (1981). However, a putative different species, *T. anepipe*, was described by Verhoeff (1939) upon some specimens, including at least a female, from

the island of Mauritius. No other specimens have been subsequently referred to this latter species, which was ignored by Demange (1981) when identifying specimens from the Seychelles as *T. javanicus*. Even though the validity of *T. anepipe* was never disputed explicitly to date, its actual distinction with respect to *T. javanicus* is dubious, because its original description, even though largely incomplete, is fully compatible with the morphology of *T. javanicus* and no distinctive characters between these two nominal species were proposed or discussed by Verhoeff (1939); worth notice is also the fact that *T. javanicus* is known to have colonised a wide tropical area, sometimes possibly introduced by man (Bonato *et al*. 2004). As *Tygarrup* populations from Mauritius and the Seychelles are, as far as known, geographically disjunct with respect to all other tropical *Tygarrup* populations, the nearest ones occurring in the Indochinese peninsula and Java, they are reasonably expected to belong to a single species.

Notes on ecology: In the Seychelles, *T. javanicus* has been recorded from wooded, internal sites in the largest islands. Worth notice is that, out of the 20 specimens collected in the Seychelles so far (Demange 1981; also orig. obs.), all 17 specimens that have been sexed are females.

Mecistocephalus Newport, 1843

Mecistocephalus Newport, 1843: 178.
Lamnonyx Cook, 1896: 61. (Synonymy: Pocock 1899: 63)
Megethmus Cook, 1896: 61. (Synonymy: Bonato *et al*. 2001: 345)
Pauroptyx Chamberlin, 1920a: 188. (Synonymy: Bonato & Minelli 2004: 20)

For other possible synonyms, see Bonato et al. (2003).

Diagnosis. Clypeus with two plagulae, separated by a mid-longitudinal areolate stripe and extending along the lateral margins of the clypeus. Buccae with spiculum and with setae at least in the posterior half. Posterior margin of labral side-pieces either entire or finely crenulated close to the mesal angles, without a fringe. Coxosternum of maxillae I with a mid-longitudinal sulcus. Coxosternum of maxillae II undivided; groove from the metameric pore reaching the lateral margin of the coxosternum. Telopodites of maxillae II overreaching those of maxillae I; claw present. Forcipular tergum with a distinct mid-longitudinal sulcus. Forcipular article I with a distal tubercle and often another tubercle at about mid-length. Sterna of leg-bearing trunk segments with mid-longitudinal sulcus either furcate or not; pore areas absent in both sexes. Number of leg-bearing segments at least 45, often invariant within a species.

Geographical distribution: widespread from tropical and subtropical Africa, through southern Asian and Indian Ocean, to Eastern Asia from Honshu to Indonesia; also in the tropical and subtropical Atlantic and Pacific regions.

Mecistocephalus angusticeps (Ribaut, 1914)

Lamnonyx angusticeps Ribaut, 1914: 23.

Published records for Seychelles: *Mecistocephalus angusticeps*: Demange 1981: 623, 628-30 (description), figs 1-2.

Material examined: 1 specimen. Picard Island (Aldabra Group): unknown locality, 9-IX-2005, 1 ♀.

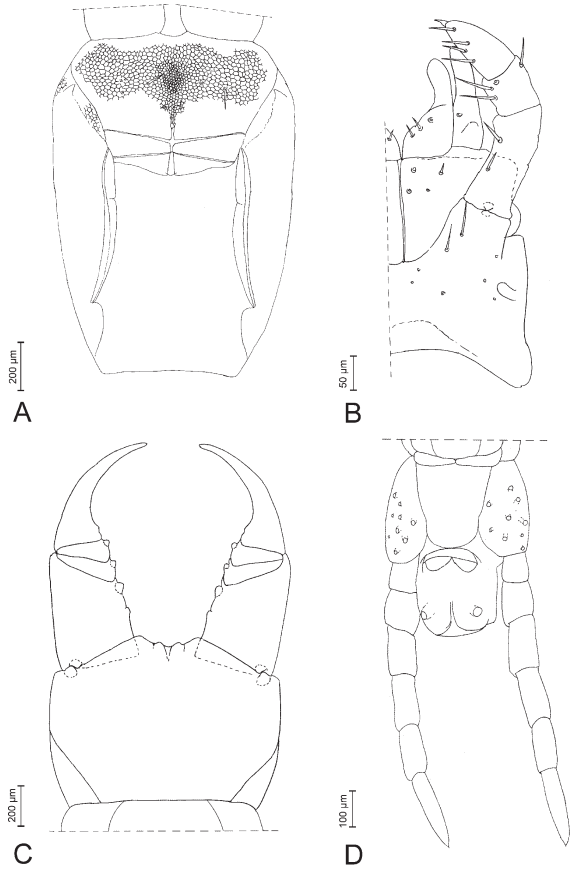

Fig. 2. *Mecistocephalus angusticeps* (Ribaut, 1914) (Picard Island, 9-IX-2005, ♀, 15 mm long): ventral view of selected parts. A, cephalic capsule without maxillae (areolation of clypeus drawn only partially). B, maxillary complex (left half). C, forcipular segment (setae not drawn). D, last leg-bearing segment and posterior tip of the trunk (setae not drawn).

Diagnosis. Body length reaching 5.0 cm. Colour yellow, with fine dark pigmentation on the dorsal side of the trunk; head and most anterior trunk segments reddish brown. Cephalic capsule ca. 1.7-1.8 times as long as wide. Frontal line uniformly concave forward. Antennae ca. 3 times as long as the head width. Antennal apical sensilla ca. 10 µm long, with a mid-length flattened circular projection. Areolate part of the clypeus longer than the plagulae, with a subcircular finely areolate medial area; ca. 3 pairs of setae on the anterior part of the areolate clypeus, arranged in an almost transversal line, and a pair of setae just anterior to the plagulae and close to the mid-line. Buccae with setae on the posterior half only. Posterior margin of labral side-pieces entire, without any evident medial projection; internal margin of the anterior ala longer than the internal

margin of the posterior ala. Mandible with ca. 7 pectinate lamellae, the first lamella bearing ca. 6 teeth, an average intermediate lamella bearing ca. 11 teeth. Coxosternum of maxillae I without projecting antero-lateral corners. Telopodites of maxillae II slender; claw uniformly tapering into a pointed tip. Forcipular article I with a small proximal tubercle and a small distal tubercle, similar to each other; intermediate articles each with a small tubercle; only a shallow emergence at the basis of the tarsungulum. Sterna of leg-bearing trunk segments with non-furcate mid-longitudinal sulcus. Invariantly 47 leg-bearing segments. Sternum of the last leg-bearing segment trapezoid, wider than long, with a notch on each lateral margin. See fig. 2.

General distribution: Kenya coast and Seychelles.

Distribution in the Seychelles: 3 localities in 3 islands. Curieuse: Baie Laraie (Demange 1981). Picard Island (Aldabra Group): unknown locality (new). Praslin: Fond de l'Anse (Demange 1981).

Taxonomic remarks: *M. angusticeps* was originally described by Ribaut (1914), under the genus *Lamnonyx* (now *Mecistocephalus*), upon a single adult female from a site on the Kenya coast. It was first assigned to the genus *Mecistocephalus* by Chamberlin (1920a). It was subsequently recorded from the Seychelles and partially redescribed by Demange (1981).

Notes on ecology: In the Seychelles, *M. angusticeps* has been recorded only from a few coastal sites.

Mecistocephalus glabridorsalis Attems, 1900

Mecistocephalus punctifrons var. *glabridorsalis* Attems, 1900: 138.

Mecistocephalus vanmoli Demange, 1981: 634. (New synonymy)

Published records for Seychelles: *Mecistocephalus punctifrons*: Brölemann 1896: 519, 528; *Mecistocephalus punctifrons* var. *glabridorsalis* Attems 1900: 134, 138 (original description); *Mecistocephalus punctifrons*: Demange 1981: 623, 627-9, 632 (redescription), fig. 3; *Mecistocephalus vanmoli* Demange 1981: 623, 626, 629, 634 (original description), figs 4-5.

Material examined: 23 specimens. La Digue: Belle Vue, 16-I-1999, 1 sex unknown. Mahé: unknown locality, 1500 m, 1965, 1 ♂. Silhouette: Anse Mondon Valley, 300 m, 29-III-2000, 1 ♀; Gratte Fesse, 400 m, 14-VII-2000, 1 ♀; same, 3-VIII-1998, 2 ♂♂, 4 sex unknown; Jardin Marron, 25-IX-1999, 1 ♀, 2 sex unknown; Mont Corgat - Mont Cocos Marrons ridge, 450 m, 18-VII-2000, 1 ♂, 1 ♀, 1 sex unknown; Mont Plaisir, 550 m, 11-VIII-2000, 1 ♀; same, 550 m, XII-1993, 1 ♂; locality unknown, 500 m, VII-VIII-1990, 2 ♂♂, 2 sex unknown; locality unknown, 20 m, 26-VII-1998, 1 ♀.

Diagnosis. Body length up to 8.5 cm. Colour yellow, with fine dark pigmentation on the dorsal side of the trunk; head and most anterior trunk segments reddish brown. Cephalic capsule ca. 1.6-1.9 times as long as wide. Frontal line uniformly concave forwards. Antennae ca. 4-5 times as long as the head width. Antennal apical sensilla ca. 13-14 µm long, with a mid-length flattened circular projection; club-like sensilla on external sides of articles from ca. VI-VII to XIV, on internal sides from articles ca. IX to XIV. Areolate part of the clypeus about as long as the plagulae, without any evident finely areolate area, sometimes with a medial non-areolate small insula just anterior of the plagulae;

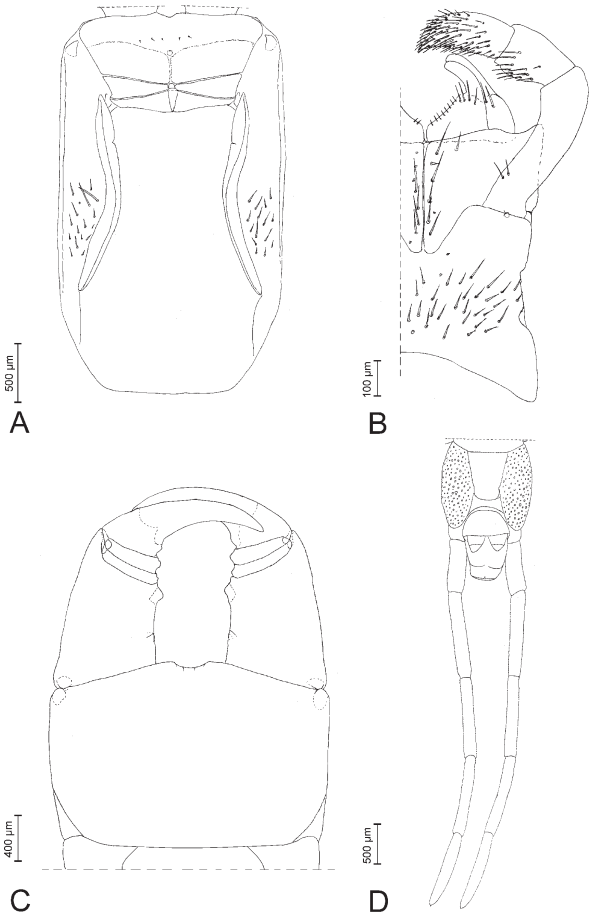

Fig. 3. *Mecistocephalus glabridorsalis* Attems, 1900 (Silhouette, 20 m, 26-VII-1998, ♀, 65 mm long): ventral view of selected parts. A, cephalic capsule without maxillae (areolation of clypeus drawn only partially). B, maxillary complex (left half). C, forcipular segment (setae not drawn). D, last leg-bearing segment and posterior tip of the trunk (setae not drawn).

ca. 4 pairs of setae on the areolate clypeus, arranged in an almost transversal line, the most medial pair usually posterior to the other ones; usually small spine-like sensilla on the anterior part of the plagulae. Buccae with setae on the posterior half only. Posterior margin of labral side-pieces entire, without any evident medial projection; internal margin of the anterior ala evidently shorter than the internal margin of the posterior ala. Mandible with up to 16-17 pectinate lamellae. Coxosternum of maxillae I with antero-lateral corners projecting forwards; no hyaline scales on the coxal projections. Telopodites of maxillae II moderately swollen; claw abruptly narrowing into a usually rounded tip. Forcipular article I with a small proximal tubercle and a large, distal

tooth relatively wide at basis, obtusely angled in profile and pointed mesally instead of forwards; intermediate articles each with a small tubercle, that of article III larger than that of article II; a small tubercle at the basis of the tarsungulum. Forcipular cerrus composed of two convergent rows of setae and a few setae on each side. Sterna of leg-bearing trunk segments with furcate mid-longitudinal sulcus, the branches diverging with an acute to rectangular angle. Invariantly 49 leg-bearing segments. Sternum of the last leg-bearing segment trapezoid, wider than long, with a notch on each lateral margin. Gonopods fully developed in females longer than ca. 3.5 cm, and in males longer than ca. 2.5 cm. See fig. 3.

General distribution: Seychelles; records by Attems (1914 1915) from Seram, New Guinea, and Bismark archipelago deserve confirmation (see under Taxonomic remarks).

Distribution in Seychelles: at least 14 localities in 4 islands. La Digue: Belle Vue (new); locality unknown (Brölemann 1896, as *M. punctifrons*). Mahé: Anse Bouganville (Demange 1981, as *M. punctifrons*); Anse Louis (Demange 1981, as *M. punctifrons*); La Misère, 438 m (Demange 1981, as *M. vanmoli*); Mont Crève Cœur, 300 m (Demange 1981, as *M. punctifrons*); Morne Blanc, 470 m and 667 m (Demange 1981, as *M. vanmoli*); Northolme (Demange 1981, as *M. punctifrons*); locality unknown (Brölemann 1896, as *M. punctifrons*); locality unknown (Attems 1900); locality unknown, 1500 m (new). Praslin: Vallée de Mai (Demange 1981, as *M. punctifrons*); locality unknown (Brölemann 1896, as *M. punctifrons*). Silhouette: Anse Mondon Valley, 300 m (new); Gratte Fesse, 400 m (new); Jardin Marron (new); Mare aux Cochons, 500 m (Demange 1981, as *M. punctifrons*); Mont Corgat - Mont Cocos Marrons ridge, 450 m (new); Mont Plaisir, 550 m (new); localities unknown, 20 m and 500 m (new).

Taxonomic remarks: *M. glabridorsalis* was originally described as a variety of *Lamnonyx punctifrons* (currently *Mecistocephalus punctifrons* Newport, 1843) by Attems (1900) upon two specimens, including a male 78 mm long, from Mahé. It was raised to the species rank by Saussure & Zehntner (1902), but subsequent authors either cited it as a variety or subspecies, or listed it as a junior synonym of some putatively widespread species such as *M. punctifrons* and *M. insularis* (Lucas, 1863) (e.g.: Silvestri 1919; Chamberlin 1920b), or even ignored it. Attems (1914, 1915) identified some specimens from South-Eastern Asia as *L. punctifrons* var. *glabridorsalis*, but these records are questionable, as the taxonomy of *M. punctifrons* was very confused at the time (see: Crabill 1970; Bonato & Minelli 2004). Even though the original description of this taxon is very incomplete and not accompanied by illustrations, and it was not subsequently supplemented prior to the present paper, the combination of the described features (mainly, large size, patched colour, head elongation, and peculiar shape of forcipular tubercles) allow us to recognise this species confidently among the material examined.

Most probably this species was already reported from the Seychelles by both Brölemann (1896) and Demange (1981) under the name *M. punctifrons*. This interpretation is supported by the following arguments: Demange (1981) re-examined the specimens previously reported by Brölemann and found them conspecific with the specimens from Seychelles that he also identified as *M. punctifrons*; all morphological details described by Demange (1981) are fully consistent with no other species than

M. glabridorsalis; Demange (1981) cited *M. punctifrons* var. *glabridorsalis* only as a nominal taxon in the introductory historical account of his paper, whereas he completely ignored it in the taxonomic list of the Seychelles centipedes in the same paper, therefore treating it implicitly as identical to *M. punctifrons*; out of the geophilomorph specimens from Seychelles studied by us, *M. glabridorsalis* turns out to be the most frequent species (accounting for 33 % of the 69 specimens), therefore it is expected to be comparatively well represented also in the sample studied by Demange (1981), where the material identified as either *M. punctifrons* or *M. vanmoli* (see below) accounts for 39% of the 54 specimens.

Mecistocephalus vanmoli was originally described by Demange (1981) upon 13 specimens, including a female 8.5 cm long, from Mahè. The species was not cited subsequently in the literature. Even though the original description is incomplete and accompanied by few illustrations, the combination of the described features (mainly, large size, patched colour, head elongation, and the pattern of forcipular tubercles) suggests that this nominal species is identical to *M. glabridorsalis*. The only putative differences given by Demange (1981) between *M. vanmoli* and the specimens from the Seychelles identified by him as *M. punctifrons* were in the body size (up to 8.5 cm in *M. vanmoli*, up to 4.0 cm in *M. punctifrons*) and in the number of pectinate lamellae of the mandible (16-17 in *M. vanmoli*, 7-10 in *M. punctifrons*). However, after examination of 23 specimens with body length ranging from 12 mm to 72 mm, we did not find any morphological evidence supporting the existence of two distinct species. Therefore, the putative distinctive characters given by Demange (1981) refer quite likely to different developmental stages of a single species. Therefore, lacking at present any evidence of taxonomic distinction, we recognise *M. vanmoli* as a junior synonym of *M. glabridorsalis*.

Worth notice is that *M. glabridorsalis* differs from both the true *M. punctifrons* (Crabill 1970; Bonato & Minelli 2004) and *M. insularis* as currently diagnosed (Lewis 1986) at least in the pattern of clypeal setae, the shape of the claw of the second maxillae and the shape of forcipular tubercles.

Notes on ecology: *M. glabridorsalis* has been collected mainly in woodland soils, in sites between 20 m and 1500 m high.

Mecistocephalus lohmanderi Verhoeff, 1939

Mecistocephalus lohmanderi Verhoeff, 1939: 77.

Published records for Seychelles: *Mecistocephalus lohmanderi* Verhoeff, 1939: 77 (original description), figs 1-3.

Material examined: 11 specimens. Aride: locality unknown, 0 m, II-1999, 1 ♂. Cousine: locality unknown, 18-III-1998, 1 sex unknown. Curieuse: locality unknown, 20-III-2002, 1 ♀. D'Arros: locality unknown, 26-VI-2003, 3 ♂♂. North: locality unknown, 0 m, 29-VII-2000, 1 sex unknown; locality unknown, 2002, 1 ♂, 1 ♀. Poivre Atoll: locality unknown, II-2005, 1 sex unknown. Silhouette: La Passe, 0 m, 16-VII-2000, 1 ♀.

Diagnosis. Body length up to 5.0 cm. Colour yellow, without dark pigmentation; head and most anterior trunk segments reddish brown. Cephalic capsule ca. 1.7-2.0 times as

long as wide. Frontal line uniformly concave forwards. Antennae ca. 4-5 times as long as the head width. Antennal apical sensilla ca. 12 µm long, with a mid-length flattened circular projection; club-like sensilla on external sides of articles from ca. VII to XIV, on internal sides of articles from ca. IX to XIV. Areolate part of the clypeus ca. 2 times longer than the plagulae, without any evident finely areolate area and without non-areolate insulae; ca. 3 pairs of setae at about mid-length of the areolate clypeus, arranged in a almost transversal line, and a pair of setae close to the mid-line, just anterior to the plagulae. Buccae with setae on the posterior half only. Mid-piece of labrum relatively wide, the side pieces evidently separated from each other; posterior margin of the side-pieces entire, without any evident medial projection; internal margin of the anterior ala evidently shorter than the internal margin of the posterior ala. Mandible with ca. 7 pectinate lamellae. Coxosternum of maxillae I with antero-lateral corners only slightly projecting forwards; no hyaline scales on the coxal projections. Telopodites of maxillae II slender; claw uniformly tapering into a pointed tip. Forcipular article I with internal margin longer than basal width; a small proximal tubercle and a distal tubercle, the distal one either similar or only slightly larger than the proximal one; intermediate articles each with a small tubercle, that of article III either similar or only slightly larger than that of article II; two small tubercles at the basis of the tarsungulum. Forcipular cerrus absent. Sterna of leg-bearing trunk segments with furcate mid-longitudinal sulcus, the branches diverging with an obtuse angle. Invariantly 49 leg-bearing segments. Sternum of the last leg-bearing segment trapezoid, wider than long, with a notch on each lateral margin. Gonopods fully developed in females longer than ca. 3.0 cm, and in males longer than ca. 2.0 cm. See fig. 4.

General distribution: Mauritius island and the Seychelles.

Distribution in Seychelles: 7 localities in 7 islands. Aride: locality unknown, 0 m (new). Cousine: locality unknown (new). Curieuse: locality unknown (new). D'Arros: locality unknown (new). North: locality unknown, 0 m (new). Poivre Atoll: locality unknown (new). Silhouette: La Passe, 0 m (new).

Taxonomic remarks: *M. lohmanderi* was originally described by Verhoeff (1939) upon a single female, 50 mm long, from Mauritius island. The species was not recorded subsequently, but its validity was never disputed. Even though the original description and illustrations are poor, the combination of the described features (mainly, body colour, elongation and areolation pattern of the clypeus, pattern of forcipular tubercles) prompt us to recognise this species among the material examined.

Relying on published information, *M. lohmanderi* is very close to other species also described from Mauritius by Verhoeff (1939), namely *M. mauritianus* Verhoeff, 1939 and *M. parvidentatus* Verhoeff, 1939. These two species, however, differ apparently from *M. lohmanderi* in the shape of labrum (the mid-piece relatively narrower, with the side-pieces almost touching each other, in both *M. mauritianus* and *M. parvidentatus*), in the elongation of forcipular article I (more stout in *M. mauritianus*, not described in *M. parvidentatus*), and in the furcation of the sternal sulci (branches diverging less widely in *M. mauritianus*, apparently inconspicuous in *M. parvidentatus*); other putative differences given by Verhoeff (1939) are in the elongation of antennal articles, the shape of areolate clypeus and plagulae, the size and shape of spiculum, and the

distance between the female gonopods, but all these are quite subjective or even variable between individuals.

Two specimens from Felicite (24-III-2001, 1 ♂, 1 sex unknown) could be assigned only tentatively to *M. lohmanderi*, as they are largely consistent with other specimens assigned to this species, only differing for a less elongate cephalic capsule (only 1.6 times longer than wide in a 25 mm long specimen) and for the presence of a cerrus composed of some setae.

Notes on ecology: In Seychelles, *M. lohmanderi* has been recorded at least from a few sites at sea level.

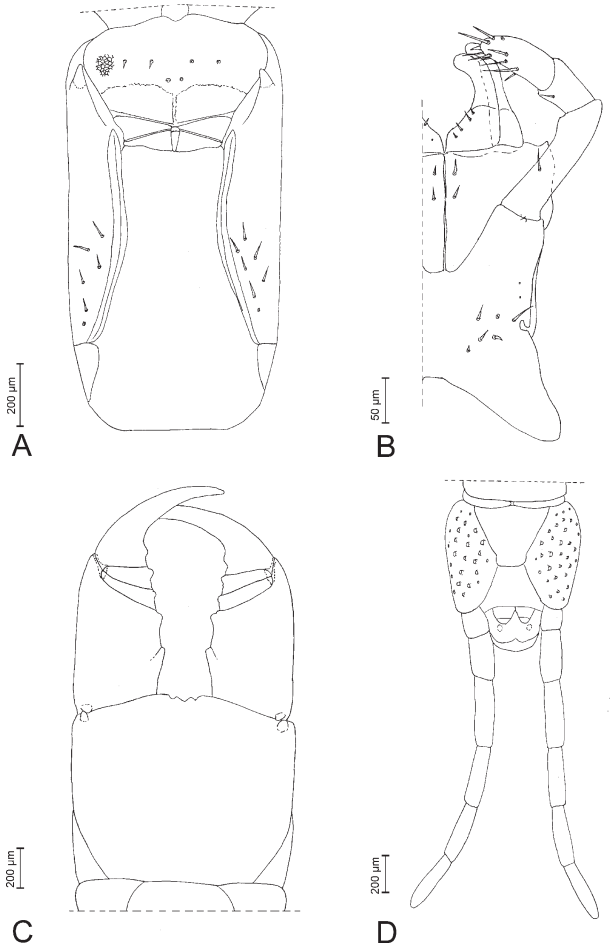

Fig. 4. *Mecistocephalus lohmanderi* Verhoeff, 1939 (Curieuse, 20-III-2002, ♀, 30 mm long): ventral view of selected parts. A, cephalic capsule without maxillae (areolation of clypeus drawn only partially). B, maxillary complex (left half). C, forcipular segment (setae not drawn). D, last leg-bearing segment and posterior tip of the trunk (setae not drawn).

Mecistocephalus megalodon Bonato & Minelli, 2009

Mecistocephalus megalodon Bonato & Minelli, 2009: 95

Published records for Seychelles: *Mecistocephalus megalodon* Bonato & Minelli, 2009: 95 (original description); figs 4, 6.

Material examined: 10 specimens. Aride: locality unknown, 0 m, II-1999, 3 ♂♂, 4 ♀♀; locality unknown, XI-2000, 1 ♀; locality unknown, 20-III-2002, 1 ♂. Cousine: locality unknown, 0 m, 13-III-1998, 1 sex unknown.

Diagnosis. Body length up to 4.5 cm. Colour pale yellow, without dark patches; head and most anterior trunk segments reddish brown, much contrasting with remaining trunk. Cephalic capsule ca. 1.4-1.6 times as long as wide. Frontal line uniformly concave forwards. Antennae ca. 4-5 times as long as the head width. Antennal apical sensilla ca. 11-12 µm long, with a mid-length flattened circular projection; club-like sensilla on external side of articles from ca. VII-VIII to XIV, on internal side of articles from ca. IX-X to XIV. Areolate part of the clypeus about as long as the plagulae, without any finely areolate area or non-areolate insula; ca. 3 pairs of setae on the areolate clypeus, arranged in an almost transversal line, and a medial pair of setae at mid-length of the plagulae, close to the mid-longitudinal areolate stripe. Buccae with setae on the posterior half only. Posterior margin of labral side-pieces entire, without any evident medial projection; internal margin of the anterior ala reduced to a point. Mandible with up to 12 pectinate lamellae, first lamella with 6 teeth, an average intermediate lamellae with about 30 teeth. Coxosternum of maxillae I with antero-lateral corners projecting forwards; no hyaline scales on the coxal projections. Telopodite of maxillae II slender; claw abruptly narrowing close to the tip and bearing a tiny, slender projection. Exposed part of forcipular coxosternum ca. 1.2 times as wide as long, anterior margin bearing a pair of elongate, pointed teeth. Forcipular article I with both proximal and distal teeth unusually elongate, pointed and projecting forwards, the distal one slightly larger than the proximal one; intermediate articles each with a conspicuous tooth, smaller than those of article I, that of article III larger than that of article II; two tubercles at the basis of the tarsungulum. Forcipular cerrus composed of two convergent rows of setae and a few setae on each side. Sterna of leg-bearing trunk segments with furcate mid-longitudinal sulcus, the branches diverging with an obtuse angle. Invariantly 49 leg-bearing segments. Sternum of the last leg-bearing segment sub-triangular, much wider than long, with a posterior swollen emergence. Gonopods fully developed in females longer than ca. 3.0 cm. See fig. 5.

General distribution: Seychelles.

Distribution in Seychelles: at least 2 localities in 2 islands. Aride: localities unknown, including 0 m (Bonato & Minelli 2009). Cousine: locality unknown, 0 m (Bonato & Minelli 2009).

Taxonomic remarks: *M. megalodon* has been described by Bonato & Minelli (2009) upon the material listed above. The unusual size and shape of the forcipular teeth are obviously distinctive with respect to all other known species of *Mecistocephalus*.

Notes on ecology: *M. megalodon* has been recorded from a few sites at sea level, including one with damp soil near a marsh.

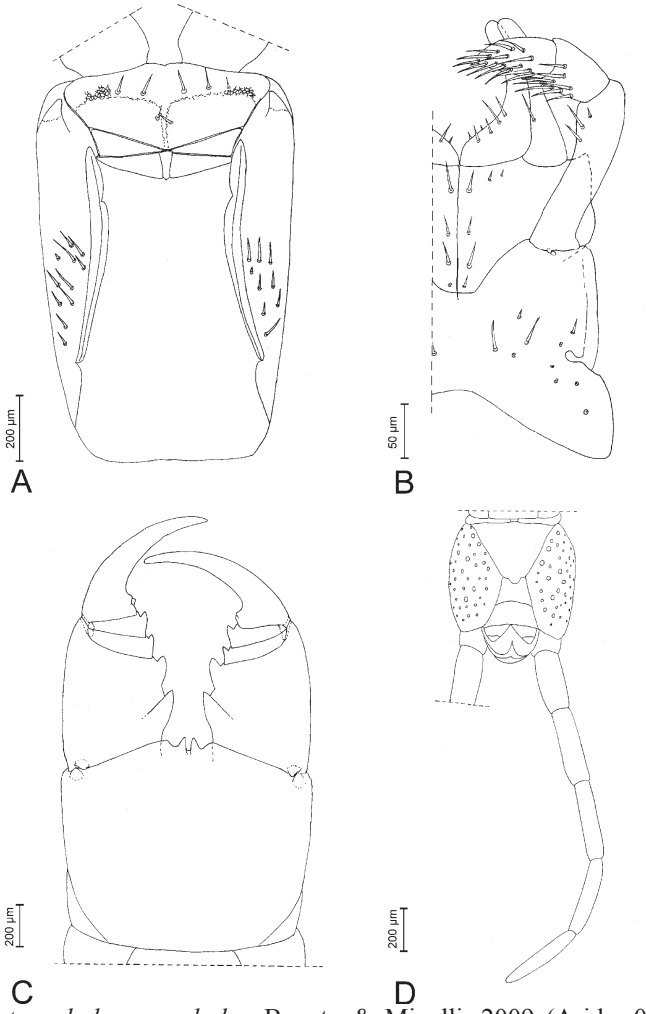

Fig. 5. *Mecistocephalus megalodon* Bonato & Minelli, 2009 (Aride, 0 m, II-1999, ♀, 45 mm long): ventral view of selected parts. A, cephalic capsule without maxillae (areolation of clypeus drawn only partially). B, maxillary complex (left half). C, forcipular segment (setae not drawn). D, last leg-bearing segment and posterior tip of the trunk (setae not drawn).

Mecistocephalus sechellarum Demange, 1981

Mecistocephalus sechellarum Demange, 1981: 635.

Published records for Seychelles: *Mecistocephalus sechellarum* Demange 1981: 623, 628-9, 635 (original description), fig. 6.

Material examined: none.

Diagnosis. Body length reaching at least 4.8 cm. Colour pale yellow, without dark

patches; head and most anterior trunk segments reddish brown. Cephalic capsule ca. 1.6 as long as wide. Areolate part of the clypeus with a finely areolate or non-areolate rhomboidal area; ca. 4 pairs of setae on the areolate clypeus, two of them posterior to the others. Posterior margin of labral side-pieces entire, without any evident medial projection. Mandible with ca. 9 pectinate lamellae, the first lamella bearing 5 teeth, an average medial lamella 8-15 teeth. Forcipular article I with a proximal and a distal tubercle, similar in size; intermediate articles each with a small tubercle; a shallow emergence at the basis of the tarsungulum. Sterna of leg-bearing trunk segments with furcate mid-longitudinal sulcus, the branches diverging with an obtuse angle. A total of 51 leg-bearing segments in the single known specimen. Sternum of the last leg-bearing segment trapezoid, about as long as wide, the anterior margin ca. one half of the posterior margin of the preceding sternum.

General distribution: Seychelles.

Distribution in Seychelles: 1 locality. Silhouette: Mont Dauban, 600 m (Demange 1981).

Taxonomic remarks: *M. sechellarum* was originally described by Demange (1981) upon a single specimen, 48 mm long, from Silhouette. This specimen was indicated as a male in the original description, but the associated illustration of its gonopods indicates that it is actually a female. No other specimens have been recorded subsequently.

Examination of further specimens is needed to confirm the distinction of this species with respect to the apparently similar *M. evansi* Brölemann, 1922, so far reported only from Iraq, as already acknowledged by Demange (1981), as well as to confirm that the number of leg-bearing segments is invariantly 51 in this species, a number only known for a few other species of *Mecistocephalus*.

Notes on ecology: *M. sechellarum* has been recorded from a single wooded site, 600 m high.

Mecistocephalus cyclops (Brölemann, 1896)

Mecistocephalus gigas var. *cyclops* Brölemann, 1896: 528.

Published records for Seychelles: *Mecistocephalus gigas* var. *cyclops* Brölemann, 1896: 528 (original description); *Mecistocephalus cyclops*: Demange 1981: 623, 638 (description) (also cited as *Mecistocephalus gigas cyclops*).

Material examined: none.

Diagnosis. Body length large (size not given). Mandible with ca. 16 pectinate lamellae. Forcipular article I with a proximal and a distal tubercle; intermediate articles each with a tubercle; a tubercle at the basis of the tarsungulum. Sterna of leg-bearing trunk segments with furcate mid-longitudinal sulcus, the branches diverging with an almost flat angle. A total of 57 leg-bearing segments in the single known specimen.

General distribution: Seychelles.

Distribution in the Seychelles: 1 locality. La Digue: locality unknown (Brölemann 1896).

Taxonomic remarks: *M. gigas* var. *cyclops* was originally described by Brölemann (1896) upon a single adult female from La Digue. The original description was very vague but it was partially integrated and emendated by Demange (1981), after re-

examination of the holotype. No other specimens have been recorded so far. This taxon was originally supposed to be closely related to *Mecistocephalus gigas* Haase, 1887, a well distinct species occurring in the Moluccas and New Guinea, but this deserves to be evaluated. The taxon was treated at the species rank both by Chamberlin (1920a) and Demange (1981).

The morphology of this species remains very inadequately known. The number of leg pairs in the only known specimen was given as 59 by Brölemann (1896), but it was emendated as 57 by Demange (1981). Worth notice is that the segmental structure of the trunk of the holotype is affected by a developmental trouble, as the right side of the

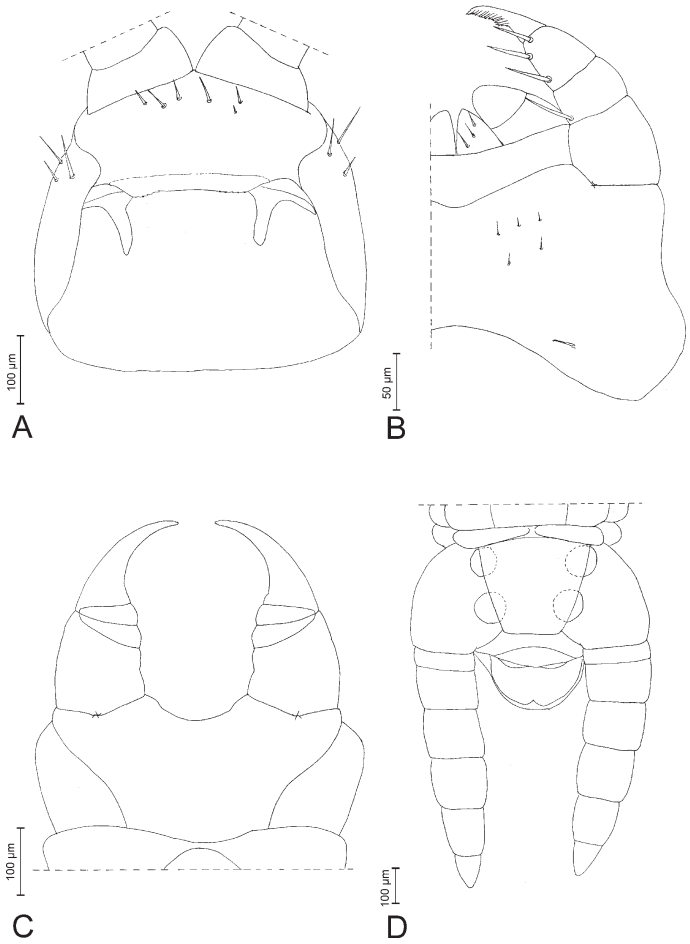

Fig. 6. *Ityphilus melanostigma* (Attems, 1900) (Mahé, Mare aux Cochons, 29-VII-2002, ♂, 19 mm long): ventral view of selected parts. A, cephalic capsule without maxillae (areolation of clypeus drawn only partially). B, maxillary complex (left half). C, forcipular segment (setae not drawn). D, last leg-bearing segment and posterior tip of the trunk (setae not drawn).

LI leg-bearing segment is described as apparently duplicated (Demange 1981). Further, within the genus *Mecistocephalus*, the number of leg-bearing segments is higher than 55 only in very few species occurring in Eastern Asia, from Japan to Taiwan (Uliana *et al.* 2007), apparently not closely related to *M. cyclops*. Examination of other representative specimens is needed to assess whether the segment number in the holotype of *M. cyclops* is actually typical of the species and whether it is intraspecifically invariant or not.
Notes on ecology: No information available.

Ballophilidae Cook, 1896
Diagnosis: Body usually tapering gradually forwards, abruptly narrowing at the posterior end. Colour either uniformly pale yellow or variously patched, often blue or green. Antennae either slender or evidently clavate and geniculate. Cephalic capsule poorly depressed, about as long as wide, lateral margins convergent forwards. Clypeus and buccae apparently not divided into an anterior areolate part and a posterior non-areolate part. Labral margin poorly chitinised, usually entire, sometimes with very few weak denticles close to the lateral ends. Mandible bearing one dentate and one pectinate lamella. Maxillae I with undivided coxosternum; each coxal projection stout and uniarticulate; each telopodite composed of two articles. Maxillae II with coxosternum non-areolate in the median part; claw of telopodite simple or bi-pectinate. Forcipular tergum about as wide as the head and the subsequent tergum. Forcipular coxosternum evidently wider than long, the anterior margin concave and without tubercles, the lateral margins strongly convergent backwards; chitin lines either present or not. Forcipules relatively short, not reaching the anterior margin of the head, without tubercles. Sterna of leg-bearing trunk segments without evident mid-longitudinal sulcus; sternal pores arranged in a single median area or two paired areas. Coxal glands of each coxopleuron opening into one or two pits, close to the lateral margin of the sternum. Telopodite of last pair of legs composed of 6 articles, evidently swollen in both sexes, not evidently longer than the telopodite of preceding legs; claw absent.
Geographical distribution: most of the tropical and subtropical continental lands and islands, namely most part of the Americas, central and southern part of Africa, Madagascar, southern and eastern Asia, Australia and some islands in the Pacific Ocean.

Ityphilus Cook, 1899

Ityphilus Cook, 1899: 306.
Thalthybius Attems, 1900: 139. (Synonymy by Demange & Pereira 1985: 188).
Thalthybius (*Prionothalthybius*) Brölemann, 1909: 334. (Synonymy by Pereira *et al.* 1994: 166).

Diagnosis: Body colour usually purple when alive. Forcipular coxosternum with evident, almost complete chitin lines. Internal margin of forcipular tarsungulum either smooth or serrate. Sternal pores arranged in a single subcircular or transversally elongate area on the anterior part of the trunk, in a single or two paired areas on the posterior part of the trunk. Coxal glands opening into two pits on each coxopleuron.

Geographical distribution: central and southern Americas, northwards to Texas, Florida Keys and Bahamas, southwards to Peruvian Andes and Amazonas; western Pacific islands, from Japan to Taiwan and Mariana Islands; also Seychelles.

Ityphilus melanostigma (Attems, 1900)

Thalthybius melanostigma Attems, 1900: 140.

Published records for Seychelles: *Thalthybius melanostigma* Attems, 1900: 134, 140 (original description); figs 10-12; *Thalthybius melanostigma*: Demange 1981: 623, 625, 629; fig. 7.

Material examined: 1 specimen. Mahé: Mare aux Cochons, 29-VII-2002, 1 ♂.

Diagnosis: Body length at least 6 cm. Colour in alcohol mainly transparent, with dark bluish patches corresponding to the sternal glands. Cephalic capsule slightly wider than long. Antennae ca. 2-3 times longer than the head width. Apical sensilla spear-like, abruptly tapering into a slender tip, ca. 10-12 μm long. Coxosternum and telopodites of maxillae I without lappets. Claw of the telopodite of maxillae II bi-pectinate. Internal margin of forcipular tarsungulum smooth. Number of leg-bearing segments 95-101 in the only three known specimens. Sternal pores arranged in a single, transversally elongated, mid-longitudinally constricted area on almost all the leg-bearing segments. Sternum of the last leg-bearing segment trapezoidal, wider than long. See fig. 6.

General distribution: Seychelles.

Distribution in Seychelles: at least 2 localities in 1 island. Mahé: Mare aux Cochons (new); Morne Blanc, 667 m (Demange 1981); unknown locality (Attems 1900).

Taxonomic remarks: *I. melanostigma* was originally described by Attems (1900) under the genus *Thalthybius* (now *Ityphilus*) upon two specimens from Mahé. The species was subsequently recorded by Demange (1981).

Notes on ecology: *I. melanostigma* has been recorded at least from a few wooded, internal sites, including one 670 m high.

Geophilidae Leach, 1815

Diagnosis: Body slightly depressed, uniformly wide or gradually narrowing forwards, variously tapering backwards. Colour from pale yellow to red-brown, head and most anterior trunk segments sometimes darker. Antennae slender, gradually attenuated. Cephalic capsule variously depressed, about as long as wide or slightly longer than wide, lateral margins either sub-parallel or convergent forwards. Clypeus and buccae not evidently divided into an anterior areolate part and a posterior non-areolate part. Labral margin usually composed of a mid-part bearing tubercles or slender projections, and two side-parts partially delimited from the clypeus and bearing slender filaments. Mandible bearing a single pectinate lamella. Maxillae I with undivided coxosternum; coxal projection uniarticulate, stout; telopodite composed of two articles, the basal one usually bearing a hyaline lobe covered with pointed scales. Maxillae II with coxosternum non-areolate in the median part; claw of telopodite usually simple. Forcipular tergum either about as wide as the head and the subsequent tergum, or slightly narrower. Forcipular coxosternum variously shaped, the anterior margin either concave or straight,

with or without tubercles and chitin lines. Forcipules variously large and elongate, usually not visible from above in front of the head; pattern of tubercles variable. Sterna of leg-bearing trunk segments usually without a mid-longitudinal sulcus; sternal pores variously arranged, sometimes absent. Coxal glands of each coxopleuron opening into either independent pores or common pits. Telopodite of last pair of legs composed of 6 articles, slender, sometimes swollen in the male, similar or longer than the telopodite of preceding legs; claw either present or not. Gonopods biarticulate in the male, coalescent into a uniarticulate lamina in the female.
Geographical distribution: mainly Americas from the Arctic lands to the southernmost areas, temperate Eurasia, most of Africa, Madagascar and Australian region, including New Zealand and some islands in the Pacific Ocean.

Tuoba Chamberlin, 1920

Tuoba Chamberlin, 1920b: 35.
Geophilus (*Nesogeophilus*) Verhoeff, 1924: 413. (Synonymy: Crabill 1968b: 345).
Algerophilus Brolemann, 1925: 251. (Synonymy by Jones 1998: 334).
Honuaphilus Chamberlin, 1926: 93. (Synonymy by Bonato *et al.* 2004: 24).

Diagnosis: Cephalic capsule about as long as wide or only slightly longer than wide. Clypeus without finely areolate areas. Labral mid-part bearing tubercles and side-parts bearing slender filaments. Coxosternum of maxillae II with a longitudinally extended bridge, without any evidently chitinised ridge and without antero-internal projections. Claw of maxillae II uniformly tapering, pointed. Forcipular tergum about as wide as the subsequent tergum. Forcipular coxosternum wider than long, with usually complete chitin lines, the lateral margins evidently convergent backwards, the anterior margin concave and without tubercles. Forcipular article I about as long as wide, internal margin very short. Forcipules without tubercles, only a small tubercle at the basis of tarsungulum. Sterna of leg-bearing trunk segments with 'carpophagus' sockets and a weak mid-longitudinal sulcus; pores arranged into a transversally elongate posterior band, which separates into a pair of areas towards posterior segments. Sternum of last leg-bearing segment trapezoidal, wider than long. Coxal glands of each coxopleuron opening into a single pit, close to the lateral margin of the relevant sternum. Last pair of legs slightly swollen in the male, slender in female, with a claw.
Geographical distribution: coastal regions and islands around the Atlantic, Mediterranean, Indian and Pacific basins.

Tuoba sydneyensis (Pocock, 1891)

Geophilus sydneyensis Pocock, 1891: 219.
Tuoba curticeps Chamberlin, 1920b: 35. (Synonymy by Jones 1998: 334).
Honuaphilus alohanus Chamberlin, 1926: 93. (Synonymy: Bonato *et al.* 2004: 24).
Algerophilus leptochilus Brolemann, 1931: 72. (Synonymy: Jones 1998: 334).

Published records for Seychelles: *Nesogeophilus leptochilus*: Demange, 1981: 623, 627, 629, 639.

Material examined: 2 specimens. Grande Terre (Aldabra Group): locality unknown, 1 ♂, 1 ♀.

Diagnosis: Body length up to 3 cm. Cephalic capsule ca. 1.0-1.1 times as long as wide; anterior margin obtusely pointed. Frontal line absent. Antennal apical sensilla spear-like, ca. 10 µm long. Clypeus with 1 anterior and ca. 6 posterior pairs of setae. Each bucca with two anterior setae. Labral mid-piece with 7-9 tubercles, each side-piece medially

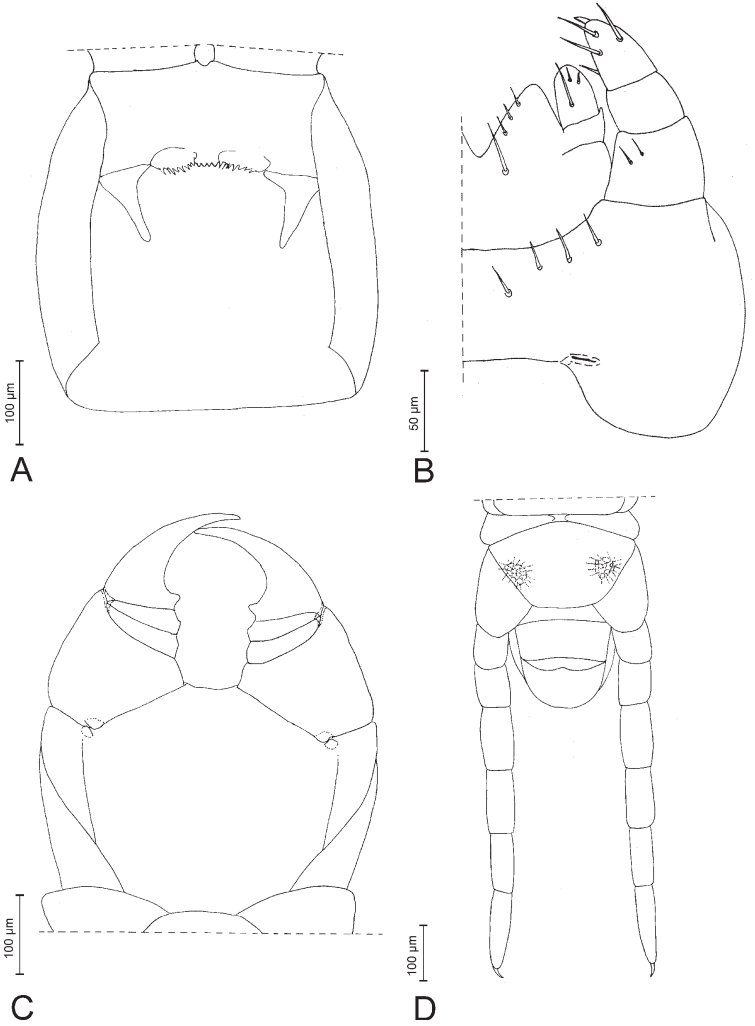

Fig. 7. *Tuoba sydneyensis* (Pocock, 1891) (Grande Terre, date unknown, ♀, 17 mm long): ventral view of selected parts. A, cephalic capsule without maxillae (areolation of clypeus drawn only partially). B, maxillary complex (left half). C, forcipular segment (setae not drawn). D, last leg-bearing segment and posterior tip of the trunk (setae not drawn).

with 2-3 tubercles. First maxillae with a pair of small lappets on the coxosternum and a pair of small lappets on the basal articles of telopodites. Claw of telopodites of second maxillae quite short. Forcipular tergum approximately as wide as that of first leg-bearing segment. Exposed part of forcipular coxosternum ca. 1.4 times as wide as long; chitin lines almost complete. Forcipules, when closed, extending nearly to anterior margin of head. Number of leg-bearing segments 39-55 (in the Seychelles: 41-43 in males and 43-45 in females). Legs with anterior parunguis longer than posterior parunguis. 'Carpophagus' socket about half as wide as sternum. See fig. 7.

General distribution: mainly between Australia and Melanesia, also Hawaii Islands and the Seychelles.

Distribution in Seychelles: 4 localities in 4 islands. Curieuse: Baie Laraie (Demange 1981). Grande Terre (Aldabra Group) (new). Mahé: Anse Louis (Demange 1981). Praslin: Fond de l'Anse (Demange 1981).

Taxonomic remarks: *T. sydneyensis* was originally described by Pocock (1891), under *Geophilus* Leach, 1814, upon three specimens from Australia. The species was first assigned to the genus *Tuoba* Chamberlin, 1920 by Crabill (1968b). It was reported and redescribed repeatedly, also under junior synonyms (Jones 1998; Bonato *et al.* 2004). The species has been already reported from the Seychelles by Demange (1981) under the name *Nesogeophilus leptochilus* (Brolemann, 1931), whose identity with *T. sydneyensis* was discussed by Jones (1998).

Notes on ecology: In Seychelles, as well as throughout its geographical range, *T. sydneyensis* has been recorded almost exclusively in littoral sites.

Ribautia Brölemann, 1909

Ribautia Brölemann, 1909: 335.

Schizoribautia Brölemann, 1912: 70. (Synonymy by Attems 1928: 172).

Polygonarea (*Nearia*) Chamberlin, 1955: 16. (Synonymy: Foddai *et al.* 2000: 90).

Diagnosis: Cephalic capsule conspicuously depressed, evidently longer than wide. Clypeus with a median finely areolate area, bearing a few setae. Labral mid-part bearing tubercles and side-parts bearing slender filaments. Coxosternum of maxillae II with a longitudinally short bridge, with chitinised ridges convergent forwards and with antero-internal projections. Claw of maxillae II uniformly tapering, pointed. Forcipular tergum narrower than the subsequent tergum. Forcipular coxosternum about as long as wide or slightly wider than long, with chitin lines, the lateral margins convergent backwards, the anterior margin slightly projecting forwards and bearing a pair of tubercles. Forcipular article I longer than wide, internal margin quite long. Forcipules with an elongate, pointed tubercle at the basis of tarsungulum. Sterna of leg-bearing trunk segments without 'carpophagus' sockets; pores arranged into a subcircular or ovoid area, which sometimes separates into a pair of areas towards posterior segments. Sternum of the last leg-bearing segment trapezoidal, wider than long. Coxal glands of each coxopleuron opening into either independent ventral and lateral pores, or into a few pits close to the lateral margin of the relevant sternum. Last pair of legs slightly swollen in the male, slender in the female, with a claw or a stout tubercle.

Geographical distribution: most part of South America from the northern Andes through Amazonas to Paranà basin, equatorial Africa, Madagascar, Seychelles, southern part of Arabian peninsula, Australia, New Zealand and New Caledonia.

Ribautia* cf. *paucipes Attems, 1953

Ribautia paucipes Attems, 1953: 124.

Published records for Seychelles: ? 'Geophilidae': Demange 1981: 627; ? 'Géophilomorphe sp.': Demange 1981: 628.

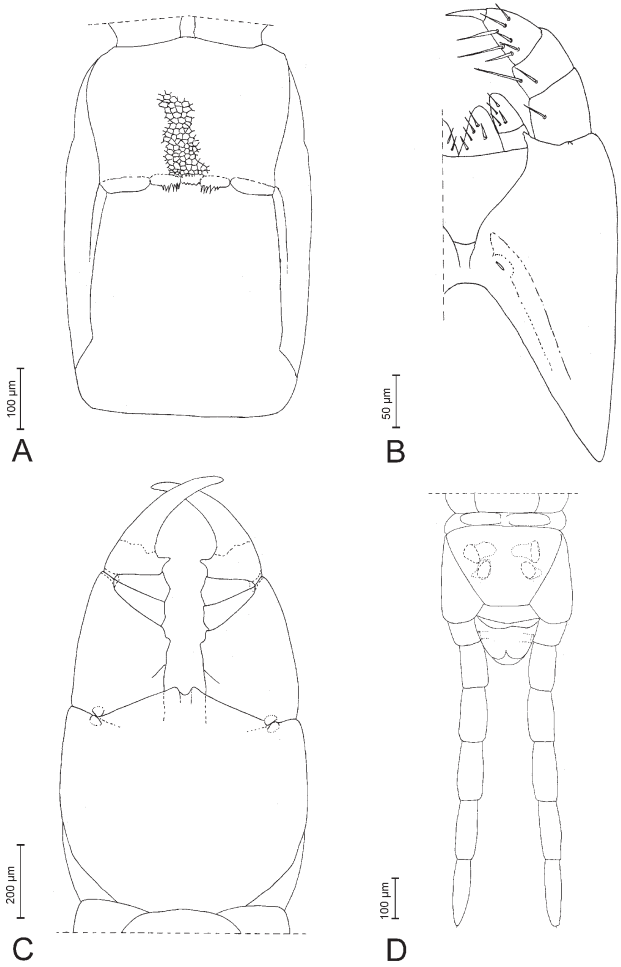

Fig. 8. *Ribautia* cf. *paucipes* Attems, 1953 (Cousine, 18-III-1998, ♀, 14 mm long): ventral view of selected parts. A, cephalic capsule without maxillae (areolation of clypeus drawn only partially). B, maxillary complex (left half). C, forcipular segment (setae not drawn). D, last leg-bearing segment and posterior tip of the trunk (setae not drawn).

Material examined: 8 specimens. Cousine: locality unknown, 18-III-1998, 5 ♂♂, 1 ♀, 2 sex unknown.
Description: Body length up to 1.5 cm. Colour uniformly pale yellow, the anterior tip slightly darker. Cephalic capsule ca. 1.4-1.7 times as long as wide. Frontal line absent. Finely areolate clypeal area bearing 4 setae. Labral mid-piece with a few tubercles. First maxillae without lappets. Coxosternum of maxillae II with elongate antero-internal projections. Exposed part of forcipular coxosternum approximately as long as wide; chitin lines almost complete. Forcipules, when closed, overreaching the anterior margin of the head. Forcipular article I without proximal tubercle, with a stout distal tubercle; intermediate articles each with a shallow emergence; basal tubercle of tarsungulum quite elongate, subconic, evidently tapering, slightly bended backwards. Number of leg-bearing segments 39-41. All sterna of leg-bearing trunk segments with pores arranged into a subcircular to oval area, which does not separate into a pair of areas towards the posterior segments. Three coxal glands on each coxopleuron, the most anterior two opening into a common pore, the most posterior one opening into an independent pore, all fully covered by the relevant sternum. Last pair of legs with a claw. See fig. 8.
General distribution: internal part of equatorial Africa; possibly also in the Seychelles.
Distribution in Seychelles: probably 3 localities in 3 islands. Cousine: locality unknown (new). ? Mahé: Morne Séchellois, 750-800 m (Demange 1981). ? Silhouette: Mont Dauban, 600 m (Demange 1981).
Taxonomic remarks: *R. paucipes* was originally described by Attems (1953) upon some specimens from localities in central Africa, encompassing the Democratic Republic of the Congo and Rwanda. It was not recorded subsequently. Based on published information, out of all known species of *Ribautia*, *R. paucipes* is the only species matching the morphology of the specimens from the Seychelles, mainly in the combination of some diagnostic traits (above all, the number of leg-bearing segments and the pattern of coxal pores). However, further investigations are needed to assess the actual taxonomic status of the populations occurring in the Seychelles with respect to the continental *R. paucipes*. Worth notice is that, based on the partial and somehow inaccurate description provided by Attems (1953), original specimens of *R. paucipes* apparently differ from the specimens from Seychelles in a few minor characters, whose diagnostic value is unknown, namely the number of setae in the clypeal finely areolate area (2 vs. 4), the distribution of sternal pores (absent in an intermediate part of the trunk, vs. present throughout the whole trunk), and the relative size of the coxal channels (one smaller than the other two, vs. all three similar).

This centipede was most probably already recorded from the Seychelles, even though not identified to the species level, by Demange (1981), who reported some unidentified geophilid specimens with 39-41 leg-bearing segments from Mahè and Silhouette.
Notes on ecology: In the Seychelles, *R.* cf. *paucipes* has been probably recorded from internal sites.

Key to the species of Geophilomorpha of the Seychelles

1. Labral sclerites well distinct from the clypeus, each side-piece with a transversal

chitinised ridge. Mandible bearing more than three lamellae. Forcipular tergum evidently narrower than the subsequent tergum. Sterna of leg-bearing trunk segments with a mid-longitudinal sulcus, without pore areas. Coxal pores numerous, scattered on the ventral surface of coxopleura. Mecistocephalidae, 2

Labrum only partially separated from the clypeus, the side-parts without a transversal ridge. Mandible bearing only one or two lamellae. Forcipular tergum as wide as or only slightly narrower than the subsequent tergum. Sterna of leg-bearing trunk segments without an evident mid-longitudinal sulcus, and with pore areas. Coxal pores few, grouped close to the lateral margin of the sternum. 8

2. Clypeus with an entire plagula. Buccae without spiculum and without setae. Forcipular article I with a distal tubercle only. Number of leg-bearing segments invariantly 45. *Tygarrup*: *T. javanicus*

   Clypeus with two plagulae. Buccae with spiculum and with setae at least in the posterior half. Forcipular article I with a proximal and a distal tubercle. Number of leg-bearing segments at least 47. *Mecistocephalus*, 3

3. Areolate part of the clypeus with a subcircular finely areolate medial area. Labrum with internal margin of the anterior ala longer than the internal margin of the posterior ala. Sterna of leg-bearing trunk segments with non-furcate mid-longitudinal sulcus. Number of leg-bearing segments invariantly 47. *M. angusticeps*

   Areolate part of the clypeus without a subcircular finely areolate medial area. Labrum with internal margin of the anterior ala usually shorter than the internal margin of the posterior ala. Sterna of leg-bearing trunk segments with furcate mid-longitudinal sulcus. Number of leg-bearing segments at least 49. 4

4. Number of leg-bearing segments more than 51. *M. cyclops*

   Number of leg-bearing segments either 49 or 51. 5

5. Body colour with dark pigmentation. Claw of maxillae II abruptly narrowing into a usually rounded tip. Forcipular article I with the distal tubercle much larger than the proximal tubercle. Number of leg-bearing segments invariantly 49. *M. glabridorsalis*

   Body colour without dark pigmentation. Claw of maxillae II uniformly tapering into a pointed tip. Forcipular article I with the distal tubercle similar or only slightly larger than the proximal tubercle. Number of leg-bearing segments either 49 or 51. 6

6. Clypeal plagulae with a pair of setae at mid-length, close to the mid-longitudinal areolate stripe. Forcipular article I with both proximal and distal tubercles much elongate and projecting forwards. Number of leg-bearing segments invariantly 49. *M. megalodon*

   Clypeal plagulae without setae. Forcipular article I with tubercles of moderate size. Number of leg-bearing segments either 49 or 51. 7

7. Labral side pieces evidently separated from each other. Number of leg-bearing segments invariantly 49. *M. lohmanderi*

   Labral side pieces almost touching each other. Number of leg-bearing segments 51. *M. sechellarum*

8. Antennae evidently clavate and geniculate. Cephalic capsule about as long as wide. Mandible bearing one dentate and one pectinate lamella. Claw of telopodite of maxillae II bi-pectinate. Forcipules without tubercles. Number of leg-bearing segments more than 90. Legs of the last pair evidently swollen in both sexes.
Ballophilidae: *Ityphilus*: *I. melanostigma*

Antennae slender, uniformly tapering. Cephalic capsule longer than wide. Mandible bearing a single, pectinate lamella. Claw of telopodite of maxillae II simple, not pectinate. Forcipules with tubercles. Number of leg-bearing segments less than 70. Legs of the last pair only slightly swollen in the male, slender in female.
Geophilidae, 9

9. Clypeus without a median, finely areolate area. Coxosternum of maxillae II with a longitudinally extended bridge, without any evident chitinised ridge and without antero-internal projections. Anterior margin of forcipular coxosternum concave and without tubercles. Forcipules without tubercles, only a small tubercle at the basis of tarsungulum. Sterna of anterior part of trunk with 'carpophagus' sockets and pores arranged into transversally elongate posterior band. Coxal glands of each coxopleuron opening into a single pit. *Tuoba*: *T. sydneyensis*

Clypeus with a median, finely areolate area. Coxosternum of maxillae II with a longitudinally short bridge, with chitinised ridges convergent forwards and with antero-internal projections. Anterior margin of forcipular coxosternum slightly projecting forwards and bearing a pair of tubercles. Forcipular article I with a distal tubercle; an elongate, pointed tubercle at the basis of tarsungulum. Sterna of anterior part of trunk without 'carpophagus' sockets and with pores arranged into a subcircular or ovoid area. Coxal glands of each coxopleuron opening into an anterior common pore and a posterior independent pore.
Ribautia: *R.* cf. *paucipes*

Faunistic remarks

As far as known, 10 species of Geophilomorpha occur in the Seychelles. Out of these, 7 species are in the family Mecistocephalidae, two in the Geophilidae and one in the Ballophilidae.

Taxonomic diversity of the mecistocephalids in the Seychelles is outstanding with respect to neighbouring islands and continental areas: Mascarene islands, Madagascar, Africa and Arabic peninsula host apparently fewer species of *Mecistocephalus*, mostly closely related to each other, while *Tygarrup* has been otherwise recorded in this area, only from Mauritius.

Out of the species occurring in the Seychelles, *Tygarrup javanicus* and *Tuoba sydneyensis* are apparently widespread through tropical areas in the Indian and Pacific basins, both having their westernmost known population in the Seychelles. Conversely, most other species have been so far recorded only from the Seychelles (*M. glabridorsalis*, *M. megalodon*, *M. sechellarum, M. cyclops*, *I. melanostigma*) or in a few other neighbouring islands or coastal localities of the African continent (*M. angusticeps*, *M. lohmanderi*). Worth notice is that no species is shared between the Seychelles and Madagascar, contrary to previous opinion (Saussure & Zehntner 1902).

Table II. Occurrence of species of Geophilomorpha on the islands of the Seychelles.

	Aride	Cousine	Curieuse	D'Arros	Felicite	Grande Terre	La Digue	Mahé	North	Picard	Poivre Atoll	Praslin	Silhouette
T. javanicus							x	x				x	x
M. angusticeps			x							x		x	
M. glabridorsalis							x	x				x	x
M. lohmanderi	x	x	x	x	?				x		x		x
M. megalodon	x	x											
M. sechellarum													x
M. cyclops							x						
I. melanostigma								x					
T. sydneyensis			x			x		x				x	
R. cf. *paucipes*		x						?					?

In addition to the species already recorded from the Seychelles, the examination of the newly collected specimens revealed the presence of two other species, namely *Mecistocephalus lohmanderi*, originally described from Mauritius island, and *Mecistocephalus megalodon*, previously unknown and described by us elsewhere (Bonato & Minelli 2009). Furthermore, the new material allowed us to contribute to elucidate the identity of species previously misidentified (*Mecistocephalus glabridorsalis*) or still not identified properly (*Ribautia* cf. *paucipes*). However, records are only from a dozen islands (table II), so that our knowledge remains quite incomplete.

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The timing of arrival of humans and their commensal animals on Western Indian Ocean oceanic islands.

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Abstract: The principal island groups, Comoros, Mascarenes, and granitic Seychelles were first settled by humans at very disparate times: The Comoros during the 8th century CE, the Mascarenes from 1638, and the Seychelles not until 1770. As the settlers in the Comoros did not chronicle their lives, evidence of commensal arrival relies on archaeology, and there is no useful historical information on these animals until Europeans began visiting in the 1500s. By contrast in the Mascarenes, although ship rats preceded the first Dutch visit in 1598, Europeans documented their releases of livestock (various ungulates) on Mauritius and Réunion in the early 1600s, and the arrival (deliberate or not) of many other species thereafter. Releases were later, not until the 1730s, in Rodrigues (though rats were there by 1691). Cats arrived in the 1680s on the larger two islands, but Norway rats not until the 1730s. In the Seychelles ship rats were present in 1773, but their arrival date is uncertain; ungulates have been feral at various times, but are now longer so. Various other commensal or human food-related mammal, bird and reptile species are now present on many of the islands. In the Mascarenes particular waves of extinctions can be related to colonisation by specific introduced mammals. The low coral islands of the area have very disparate human and feral animal histories; details are given for the Aldabra group, the only low islands with significant endemism.

Introduction

The three principal groups of oceanic high islands in the western Indian Ocean have very different histories of human discovery and settlement. The Comoros, lying between mainland Africa and Madagascar, may have had temporary settlements from 1000BCE, but were settled permanently in the first millennium CE. The settlement history here is closely tied to that of the interactions of Austronesians (proto-Malagasy) and native East African groups in the 7th and 8th centuries CE (e.g. Dick-Read 2006, Allibert 2007). By contrast the Mascarenes and the granitic central Seychelles, far out beyond Madagascar, where not formally discovered until the 16th and 17th centuries, and not settled till the 17th and 18th; however there is some evidence of earlier non-European sightings and (in the Seychelles) visits.

To keep this review within bounds, I have confined my analysis to those islands with land vertebrates endemic at the specific level or higher. These comprise the 'high' (volcanic and granitic) islands, and the raised coralline islands of the Aldabra group. The numerous low islands, as follows, are thus excluded: Maldives, Chagos (BIOT, to UK), Amirantes, Providence/Farquhar (to Seychelles), Agalega[1] & St.Brandon/Cargados (to Mauritius), the French 'Isles Eparses' (Tromelin, Glorieuses & the Mozambique Channel low islands) and the low islands of the central Seychelles (Denis & Bird, and outliers Coëtivy & Platte). Denis and Bird now harbour some Seychelles endemic lizards (Cheke 1984, probably introduced), Bird also has the sunbird *Nectarinia dussumieri*

1. Agalega has an endemic race (*P. b. agalegae*) of the Réunion forest day-gecko *Phelsuma borbonica* (Cheke & Lawley 1984), the only low island apart from the Aldabra group with any vertebrate endemism.

(introduced in 2006, Gerlach 2007), and the Seychelles race *rostrata* of the ubiquitous *Nesoenas* (formerly *Streptopelia*) *picturata,* and Denis the Seychelles Fody *Foudia sechellaru*m (introduced 2004, Gerlach 2007[2]).

Humans inevitably brought both livestock deliberately and facultative commensals by accident to all these islands. In this paper I am taking 'commensals' to include domestic livestock, whether escaped or deliberately released (goats, cattle, pigs, chickens, guinea-fowl, bees), other animals kept or released primarily for food (deer, tenrecs, lemurs, tortoises, giant snails), anthropophilic species that arrived through this association (rats, mice, house shrews, house geckos), plus a few others (e.g. cats, civets, domestic pigeons) with other or additional functions in human society. Apart from cats, I have not considered biological control agents (nor most of the pests), animals intended purely as sporting targets (game-birds, ducks) or escaped cage-birds, although several of these have had important roles in altering or degrading ecosystems. In general I have related the animal imports to the settlement pattern, and so most of my discussion relates to the 18th century and earlier. The issue of commensal plants is also extremely important, and their invasion of islands often synergistic with introduced animals, but it is outside the scope of this paper.

As the introduction dates of commensals has been covered in less detail in the published literature, I have given more space to the Comoros and the Seychelles than the Mascarenes, which are covered in Cheke (1987) and treated more fully in Cheke & Hume (2008). However information here should not be considered definitive, as there is probably more to be gleaned from more obscure literature, and from unpublished sources, such as the English ship's logs noted by Allibert (1984) in his list of early visitors (1557- 1819) to the Comoros. This paper is an extended version of a talk given at the conference on "Evolution and extinction of the terrestrial biota of the western Indian Ocean archipelagos" held at the Linnean Society in London on 1-2 October 2009.

Comoros

As the first unequivocal historical records of the Comoros are as recent as the 12th century CE (el-Edrisi's *Description of the world,* 1154; e.g. Gevrey 1870, Allibert 1990, Liszkowski 2000), there is no accurate written dating of the first discovery or

Table 1. Discovery and settlement of the major Western Indian Ocean islands

Island/group	First sighted (documented)	First landing (documented)	First settled
Comoros	?	[? 1000 BCE]	7thC CE, Africans
Mauritius	1516, Portuguese (+ earlier Arabs)	1598, Dutch	1639, Dutch
Réunion	1510, Portuguese	<1528, Portuguese	1660, French
Rodrigues	1528, Portuguese	1601, Dutch	1735, French (from Mauritius)
Granitic Seychelles	1503, Portuguese	1609, English	1770, French (from Mauritius)
Aldabra	?, Arabs	1742, French (from Mauritius)	1880, Seychellois

2. The Seychelles Fody also thrives on D'Arros, an atoll where it was introduced in 1965 (Gerlach 2007).

settlements, although there is some archaeological evidence. The generally accepted oldest recorded sites are on Mohéli[3] (Mdjini) and Mayotte (Koungou, Dembeni 1), both ceramic and carbon-dated to the 8th century CE, with 9th century sites confirmed on Grande Comore and Anjouan (Wright 1984, Allibert & Verin 1996, Allibert 2002, Louette *et al.* 2004). However there are suggestions from recent excavations of the presence of stone-age people of African origin on at least Grande Comore on the 5th century BCE or earlier, together with domestic animals (Walsh 2007[4]), potsherds under a layer of volcanic ash dated to the 7th century CE (Allibert & Verin 1996: 468, footnote), and there is a (possibly anomalous) charcoal date of 40CE on Anjouan (Wright 1984). Some orally transmitted accounts of the islands' settlement refer to the islands being originally uninhabited and also support a first colonisation on Grande Comore that failed, followed by permanent settlement later (Kana-Hazi 1997, Verin & Saleh 1982), although the legendary ethno-chronology is wholly unrealistic[5]. The early settlement remains to be confirmed, but the islands have certainly been inhabited continuously for the last 1300-1400 years, by first Africans, then (proto-)Malagasy, Arabians, & 'Shirazi' (Gulf) peoples; the dominant languages remain island-specific dialects related to Swahili (Walsh 2007). The first European (Portuguese) eye-witness description dates from 1529 (Grande Comore, no landing) and more fully in 1557 (Allibert 1984), but there very little on the fauna, domestic or otherwise, before 1599; there is a brief Portuguese second-hand account from 1506 (Liskowski 2000) which mentions cattle, goats and chickens on the islands as a whole.

The 8th century settlers at Koungou and Dembeni (site 1) on Mayotte had cattle, goats (2 breeds), chickens, cats *Felis* (*sylvestris/lybica*) *'catus'*, and ate giant snails *Achatina fulica*, lemurs (*Eulemur* spp.), tenrecs *Centetes ecaudatus,* land tortoises *Asterochelys yniphora* and terrapins *Erymnochelys madagascariensis* (Allibert 1989, Allibert & Verin 1996), the last four endemics imported from Madagascar[6]; rats *Rattus rattus* were also present. Allibert (1989) suggested the Malagasy animals were collected by hunting parties going to the Red Island, but all could have been kept and/or released for local hunting. A layer of *Achatina* shells marked the horizon above which archaeological remains were found, suggesting they may have been the first deliberate import, followed by a population explosion. By the 9th-10th centuries there were tenrecs and goats on Anjouan (Sima), and on Grande Comore (M'Bachile), in addition to goats, remains of mice *Mus musculus* and a single pig tooth were found, tentatively identified as *Sus scrofa* (Wright 1984). Rats first appear on Anjouan in the 11th century, and chickens there around the same time (Wright 1992). Sheep are not confirmed until

3 I use the familiar French island names here, but in Comorian they are known as Mwali (Mohéli), Maoré (Mayotte), Ndzuani (Anjouan) and Ngazidja (Grande Comore); Anjouan was known in English as 'Johanna' in the 19th and earlier centuries.

4 According to Comorian press reports, Tanzanian archaeologist Felix Chami has carbon-dated material from a site at Hawengwe to 1000BCE (e.g. Ahamada 2008), but there has as yet been no formal publication to support this.

5 The first inhabitants are dated to shortly after the death of the biblical King Solomon (which chimes with the 1000BCE early settlement date), but are also said to have been Portuguese with African slaves! See Allibert (1984) for some variants of these tales.

6 Wright (1984, 1992) refers to tenrecs and lemurs as native to the Comoros, a view categorically refuted by zoologists (e.g. Louette et al. 2004)

the 11-12th sites on Mayotte (Wright 1984). The first records of rats and mice are earlier than any on Madagascar (11thC; Duplantier *et al.* 2002, Goodman *et al.* 2003); rats are repeatedly found in archaeological sites, but there are no other early Comorian finds of mice. Both rodents probably spread around all the islands at an early date.

Feral pigs exist on Mayotte and were present until recently on Grande Comore (Louette *et al.* 2004), but no other ungulates still have feral populations. The pigs are feral *Sus scrofa* (Louette 1999, Louette *et al.* 2004), not African bush pigs *Potamochoerus larvatus* as has been widely claimed (from Benson 1960 onwards, e.g. Lever 1985 & numerous websites - see Walsh 2007:101). However Keller (1901), writing in the1890s, stated that "there were formerly many swine in Mayotta that had run wild, but they are now extirpated", suggesting there may have been an earlier population (of bush pigs ?), subsequently replaced by a later release or escape of domestic pigs; however his remarks are unattributed and he didn't go there himself. Introduced bush pigs (Paulian 1961, Goodman *et al.* 2003), are common and long-established (e.g. Sganzin 1840) in Madagascar, the likely source for Mayotte. However two days of trekking in the forests and abandoned clearances in 1838[7] produced no pigs for Leigh (1849), though he mentioned several bird species, flying-foxes, guinea fowl, lemurs and feral cattle[8], and there's equally no hint in Gevrey's (1870) extended commentary on Mayotte of wild pigs, though domestic ones are briefly mentioned. Zoological collector François Pollen mentioned no pigs (feral or otherwise) on Mayotte in 1863 (Schlegel & Pollen 1868), though he discussed bush pigs in Madagascar at length. Milne-Edwards & Oustalet (1888), claiming to compile a complete list of mammals and birds in the islands, are equally silent. Nicoll (1908), visiting Mayotte in 1906, referred to lemurs and tenrecs, but said nothing of pigs. The substantial negative evidence suggests that there were no feral pigs on Mayotte between 1840 and 1906[9], and that the animals now present escaped or were released sometime between then and Benson's visit in 1958. Alone of the Comoros, Mayotte has an ancient population of Malagasy origin, the Shi-Bushi (=Ki-Buki) who were not Islamised until the (mid?) 19th century (Hébert 1991), and thus, unlike the other islands, might have appreciated a population of wild pigs for hunting. In contrast, pigs were so abhorred by the Muslim inhabitants of Mohéli, that when Leguével (1840) was shipwrecked there in 1828, and two of the ship's pigs came ashore, they were killed instantly, together with his pet dog. Seventeenth century English and Dutch visitors, reporting on supplies acquired or available in the islands, never mentioned pigs on Grande Comore, Moheli or Anjouan; they do not feature in a very full description of Anjouan in 1743 (Braad 1753), and are specifically stated as absent there in 1813 by Prior (1819) - this probably reflects their by then solidly Muslim populations. Mayotte, with treacherous reefs, was however rarely visited by

7 Leigh did not date his visit 'a few years since', but Allibert (in Liskowski 2002) gave it as September 1838; Leigh's 'king' of Mayotte 'Dansulu' (=Adrian Souli of Gevrey 1870) is currently spelt Andriantsoly (Verin 1994, Harpet 2002).

8 At this date Mayotte had been depopulated by the slave trade and emigration due to endless wars (Gevrey 1870), and cattle had apparently been abandoned to go wild (Leigh 1849).

9 German naturalist Alfred Voeltzkow travelled the islands in 1903, but unfortunately kept only to the shore and reefs in Mayotte (Voelzkow 1904).

Europeans (Allibert 1984, Liszkowski 2000), who left us only minimal details prior to the mid-19th century; goats, cattle and chickens feature (Allibert 1984: 123), but no pigs. The characterisation by the ruler of Anjouan in 1818 of the pre-Islamic inhabitants as savages who killed wild pigs and goats with sticks (Verin 1994: 62) must surely be considered apocryphally metaphorical.

The early (8th-10thC) sites all contain ungulate bones which, where identification is possible, have been confirmed as goats (Wright 1984, 1992, Allibert 1989), whereas sheep are mentioned for the 11th century on Mayotte (Wright 1984), but not at the same period in Anjouan (Wright 1992). The first Europeans recorded goats very generally: on the Comoros (island unspecified) in 1506 (Liszkowski 2000), and on all the islands individually during 1599-1614 (accounts in Purchas 1624-26, vols 2 & 4 and Grandidier *et al.* 1903-20, vols 1-2), after which they are regularly noted. By contrast 17th century European travellers mentioned sheep only four times that I can find: on Anjouan in 1614 (van den Broecke; Grandidier *et al.* 1903-20, 2:90; Newitt 1983), and on Moheli in 1602, 1607 and 1615 (Pyrard *in* Gray & Bell 1887; *Gelderland* visit as quoted by Saris in Purchas 1624-6, vol.2: 497; Roe, in Foster 1926). However by the mid-18th century Braad (1753) reported that "large flocks of sheep and goats abound" on Anjouan in 1751, though Prior (1819) specifically commented for Anjouan in 1813 that "sheep, swine, horses, mules, asses and dogs have not been introduced". Sheep (and cattle) are mentioned as raised in large numbers in the islands as a whole in the late 19th century (anon. 1911). There are no feral goats today (Louette *et al.* 2004), and sheep were probably never feral. Domestic cattle and chickens are mentioned by nearly all 17th and 18th century visitors; apparently feral cattle were encountered on Mayotte in 1646 (Smart *in* Grandidier 1903-20, 5:496).

Feral cats may be under-reported, but were recorded from Anjouan in the 1880s (Milne-Edwards & Oustalet 1888) and 1950s (Benson 1960[10]), and have been observed recently (Louette *et al.* 2004) on Mayotte and Grande Comore. Ship rats are on all four islands, but there is no evidence of Norway rats *R. norvegicus* (*ibid*., *contra* Benson 1960). Lemurs were reported by early European visitors (e.g. on Anjouan in 1655, Mundy 1608-67). They were still eaten a century ago (e.g. Schlegel & Pollen 1868, Nicoll 1908), but are largely nowadays instead both persecuted as fruit pests and sought after as pets (Walsh 2007), though old habits die hard - on Mayotte some are still eaten as a traditional 'picnic' in the field, despite CITES and official protection (Harpet 2002). *E. fulvus* is present on Mayotte, and *E. mongoz* on Anjouan and Moheli[11]. Tenrecs, presumably long feral, escaped the notice of Europeans until the 19th century (e.g. Sclater 1864, Anjouan, Moheli; Peters 1869, Grande Comore); they are established

10 Benson's (1960) hearsay report of a wild 'lynx' on Anjouan, attributed to *Felis lybica caffra*, appears to have been based on feral cats from Anjouan being identified as '*Felis cafra*' by Milne-Edwards & Oustalet (1888).

11 Grant (1801), plagiarising an unacknowledged source, reported the presence on Anjouan of, in addition to the 'mungoo' (*Eulemur mongoz*), the 'mauaulo', clearly from the detailed description *Lemur catta.* It is thus possible this species was also feral at one time. Grant also briefly mentioned a 'black mauaulo', apparently *E. fulvus*. Prosperi (1957), presumably in error, claimed that both *E.fulvus* and *E. macaco* were wild on Mayotte.

on all four islands (Louette *et al.* 2004). Ploughshare tortoises, already found in 8th-14thC middens (above & Walsh 2007), were still being traded as food into the islands during the 17th to 19th centuries (Walsh 2007). Prior (1819) listing domestic animals stated that "bullocks, goats, poultry and the *land tortoise* are numerous" on Anjouan in 1813 [my italics], and indeed the first specimen known to science originated on Grande Comore, bought ca.1885 by Humblot from Arab sailors (Bour 2007). There is no evidence this species went feral, but Prior's remarks suggest they may formerly have been kept domestically quite extensively, as Radiated tortoises *A. radiata* have been in Réunion since the early 19th century (Cheke & Hume 2008 & below).

We have no data on when guinea-fowl *Numida mitrata,* house geckos nor honey bees *Apis mellifera* arrived, although guinea-fowl and honey are mentioned among local products in the early 17th century - Sir Thomas Roe wrote of 'hunny' at 'Molalia' (=Moheli) in 1615 (Foster 1926) and Peter Mundy reported 'Guinny henns', also on Mohéli, in 1628 (Mundy 1608-67). Feral guinea-fowl survive on Grande Comore and Anjouan (Louette 2004); on Mayotte, while common in the mid-1800s (e.g. Leigh 1849), and still present in 1958 (Benson 1960), they are now extinct (Louette 1999, Clément *et al.* 2008). Domestic pigeons *Columba livia* are kept in the Comoros, apparently increasingly, but do not appear to have established fully wild populations (Louette 1988, Louette *et al.* 2004); they were no doubt introduced originally by Europeans. Four species of *Hemidactylus* inhabit houses in the Comoros (Carretero *et al.* 2005), but nothing is known of their history, and 2 species may be native (see origins section below).

The Comoros share with Madagascar and the east African islands (Zanzibar etc.) the presence throughout of the Small Indian civet *Viverricula indica*, apparently brought long ago from India for its commercially important scent glands (Louette *et al.* 2004, Walsh 2007). Indian traders were active in the area by 11thc century, and probably well before (Dick-Read 2006, Beaujard 2007), but the earliest attested date for the civet I have found is from the mid-1820s on Anjouan where Leguével (1840) witnessed a civet hunt (for musk). Schlegel & Pollen (1868) added Mayotte, Milne-Edwards & Oustalet (1888), Grande Comore, and Voelzkow (1904), Moheli. The house shrew was recorded from Grande Comore in the 19th century (Hutterer & Tranier 1990), and apparently also on Anjouan (Sclater 1864[12]), but there are no recent (or archaeological) records (Louette *et al.* 2004). The current distribution of introduced animals is discussed by Louette *et al.* (2004), who also include a survey of the vegetation and its alteration through human activity.

Mascarenes

Out on the other side of Madagascar, the Mascarenes appear on Arabian charts in the 14th century, but there is no evidence of landing until the Portuguese appeared in

12 "A Rat with a musky odour, is also a great annoyance in Joanna, tainting wine, sugar and anything it may pass over" - John Kirk's description, quoted by Sclater, exactly matches the classic lore of the rat musqué in the Mascarenes (Cheke & Hume 2008:106, 310). It is a mystery why this successful animal, apparently established on two islands, should have died out; it is perhaps preyed on by Indian civets, absent in the Mascarenes.

the 1500s, and even then the only recorded landfall was on Réunion, sometime before 1528 (North-Coombes 1980). They apparently left goats, as 'flocks' were reported by the next recorded landing in 1612 (Cheke & Hume 2008, from which the rest of the Mascarene section is also drawn). The ship rats present on Mauritius prior to the first recorded landing in 1598, by Dutch mariners, probably came from shipwrecks - the Dutch found evidence of one. Rodrigues, with a nearly complete fringing reef, was very hard to land on, and after a brief reconnaissance in 1601, was rarely visited until Leguat's party of intended colonists was deposited there in 1691; ship rats were by then already present. Current distributions of introduced species, and full details of their spread and, in some cases, extinctions, can be found in Cheke & Hume (2008), as can a detailed examination of human impact on the islands' ecology.

Mauritius

It was the habit of the European East India companies to carry livestock both for fresh meat on board but also for release on island way-stations to provide a food source for future visits, even if there was no settlement or intention to settle. In Mauritius the Dutch documented the release of chickens (short-lived) on their first visit, and goats, cattle and pigs in 1606[13]. Monkeys *Macaca fascicularis*, first recorded in 1606, were probably unwanted pets released on the homeward journey of the 1598 ships in 1602. Mauritius was a popular stopping place for ships of several nations in the early 17th century, being blessed with two large safe natural harbours and abundant feral ungulates, in addition to endemic giant tortoises *Cylindraspis* spp., popular for curing sailors' scurvy.

Mauritius was settled temporarily during 1638-1658, during which time a fourth ungulate, the deer *Cervus timorensis* was introduced in 1639 from Java, as were domestic pigeons. After a hiatus the Dutch returned in 1664 and remained until 1710, though human numbers stayed small. To judge from a sudden decline of ground-nesting birds in the late 1880s, cats *Felis catus* probably appeared around 1885, but their release

Table 2. Introduction of domestic meat animals 1: Herbivores (sheep & chickens which rarely go feral omitted). Ex = feral population extinct (and in subsequent tables)

Island /group	Cattle	Goats	Pigs	Deer	Rabbits
Comoros	9thC.Ex	?[<<1506].Ex	?? Ex + 20thC	19thC.Ex	-
Mauritius	1606.Ex	1606.Ex	1606	1639	18thC.Ex
Réunion	1649.Ex	<<1612.Ex	1629.Ex	1758.Ex + 19thC	-
Rodrigues	1862.Ex	c1730.Ex	<1795.Ex	1862.Ex	19thC.Ex
Granitic Seychelles	1771.Ex	1740s ? .Ex	<1773.Ex	19thC.Ex	-
Aldabra	-	<1878 [1867 Astove]	- [Astove only, 20thC]	-	- [Cosmoledo only, 20thC]

13 There is no evidence whatever for Hachisuka's claim (1953:2) that the Portuguese introduced "hogs, goats and fowl" in 1512, nor for the long-standing claim that they introduced monkeys (see Cheke & Hume 2008:76).

was undocumented, the first report being in 1709. The departing Dutch in 1710 left some deserters and escaped slaves, although there is no record that any were still present when the French from Réunion re-established a permanent human presence in 1722 -pirate and other ships calling in the interval may have taken them off. The 18th century saw the release of various gamebirds, beginning with guinea-fowl *Numida melaeagris* from Madagascar (which the French released as 'game' rather keeping them as livestock). Norway rats appeared around 1735, and house shrews *Suncus murinus* in the 1760s. Mice are first mentioned in 1753 (but may have been missed), and honey bees *Apis mellifera*, surprisingly, are only recorded for the first time in 1768 (Bernardin 1773, Mamet 1993), although they are likely to have been brought from Réunion by the first settlers, as claimed by Staub (1993; in 1721 according to Crane 1999, citing no source). Of the other animals under consideration, giant snails from Madagascar, initially *A. fulica*, were well-established by 1781, *A. immaculata* appearing in the 1840s; both were introduced deliberately. Tenrecs were released around 1785, rapidly became an important food source for African and Malagasy slaves. House geckos (initially *Hemidactylus frenatus*) are first noted in 1770; by the turn of the century *Gehyra mutilata* was also present; since then *H. brookii* and *Hemiphyllodactylus typus* have also appeared. Rabbits *Oryctolagus cuniculus*, imported early in the French occupation, never established on the mainland, but were feral on several offshore islets in the 19th century, surviving on Round Island until eradicated in 1986. After native tortoises ran out, large numbers were imported for food from first Rodrigues (*Cylindrapsis* spp.), then the granitic Seychelles and finally Aldabra (forms of *Dipsochelys dussumieri*), and small stocks of the last were (and are) maintained by captive breeding. The only feral population was on offshore Flat Island 1883-1950s, though there have been recent releases on island reserves as part of ecosystem restoration. The history of feral descendants of domestic pigeons is unclear – there is no evidence that the 17thC Dutch imports went wild, and only kept birds are mentioned in the 18th and early 19th centuries, but feral pigeons were common by 1859 (Cheke 1987, Cheke & Hume 2008: 322 [note 81]).

The northern offshore islets of Mauritius (up to 24 km distant) have a rather different history from the rest of the island which is worth mentioning briefly. Round Island acquired rabbits and goats in the 19th century, but no rats; other islets (Flat & Gabriel Is., Gunners Quoin) also acquired lagomorphs (rabbits & black-naped hares *Lepus nigricollis*), but also by the mid-19th century, rats - not to mention feral donkeys *Equus asinus* on Flat, which had also been used for grazing in the late 18th century. Introduced mammals have been exterminated on all these islets in recent decades.

Réunion

Pre-settlement Réunion was a less popular stopover than Mauritius, as it lacked natural harbours. As in Mauritius visitors left livestock long before the island was settled - English mariners releasing pigs and adding more goats in 1629, the French adding cattle in 1649. Occasional dissidents from the French outpost at Fort Dauphin in Madagascar were exiled there in the 1640s and 1650s, but there was no permanent settlement until 1665. Initially the island was still rat-free, but ship rats arrived in the mid-1670s, followed by cats ca.1685 (again inferred from avian extinctions, confirmed

by retrospective reports in 1703 & 1705). Honey bees were introduced in 1666. The pattern in the 18th century echoed that in Mauritius: guinea-fowl and short-lived rabbits in ca.1715, Norway rats in 1735, house shrews around the same time (but died out), deer (short-lived) in the 1750s, giant snails in the 1780s and tenrecs in 1801-2. Mice were first reported in 1754, but may have been around for some time by then. Unlike in Mauritius, feral pigs (here probably of European origin) were killed out through hunting by c1800, though there was a resurgence in the 1860s and 1870s; deer were re-introduced from Mauritius around 1900. Guinea-fowl died out around 1790. Monkeys were kept out by legislation and vigilance, but lemurs *Varecia variegeta* (escaped pets rather than food) established, probably in the 1820s, and persisted until the later 1870s. House geckos, probably present for decades, were first noted in 1801, and not identified to species before the 1860s, which is also when house shrews reappeared after a gap of 120+ years. The same four house gecko species found in Mauritius are present in Réunion. Domestic pigeons are mentioned in 1705, but apparently feral birds were first reported in 1801, being widespread by the 1860s (Cheke 1987). Giant snails *A. fulica* were introduced for bizarre medical reasons in the 1780s[14]; *A. immaculata*, introduced at an unknown date, is now more abundant. As in Mauritius, tortoises from the same sources were imported when the native ones became extinct, but here an especially large trade developed in Radiated tortoises from Madagascar (Bour 1981), which from the 1830s have been kept and bred in large numbers initially for food and in more recent years as domestic pets, though they have not become feral.

Rodrigues

Two-year stays by Leguat's party 1691-3 and English pirates in 1707-9, and a 9-month stranding by Tafforet and crew in 1725 added no commensals to the ship rats already present. Tafforet's mission was to take possession for France and establish a settlement, but his ship was blown off the island after only an advance party, but not the settlers, had landed, and the project aborted. However the early years of the 18th century saw increasing use of the island by trading ships to harvest tortoises, and eventually in 1735 the French in Mauritius set up a small settlement for that sole purpose. Meanwhile, sometime between 1725 and 1733, one of the passing ships had left goats. By 1755 the island had feral cats, and by 1761 domestic cattle, sheep, chickens and ducks; pigs brought in later had gone feral by 1795, which was also when mice were first reported. The tortoises ran out in the 1760s, and apart from a handful of people the island was deserted until permanently settled by new colonists from 1792. Guineafowl, common in 1833, were probably released around 1805; they were eliminated in the wild as agricultural pests in the 1960s, but free-ranging, possibly feral, birds were seen in 1999 (Showler 2002). Rabbits from about the same early 19thC date were apparently briefly feral on the mainland, and into the 1970s on the offshore islet île Frégate. While deer were introduced into Mauritius for food, their release on Rodrigues in 1862 was purely

14 Mead (1961) transferred this account to Mauritius based on an account from Bosc in 1803, but the 'Mauritius governor' in question was actually in charge of Réunion, two decades before the 1803 story (Cheke & Hume 2008).

for ‘sport’; they were shot out in the 1950s. House geckos *Gehyra mutilata* first noted in 1874 are likely to have been there a long time, likewise bees, not reported before 1914 (Bertuchi 1923); other house geckos (*Hemidactylus frenatus, H. brookii, Hemiphyllodactylus typus*) are now also present; the native *Lepidodactylus lugubris* also uses houses extensively. Domestic pigeons were late arrivals; absent in 1874, they were first reported, already feral, in 1914 (Showler 2002). Bones attributed to Norway rats were found in 1874, but the first mention of them alive dates from 1914; giant snails, apparently absent before 1917, were formally recorded only in the 1960s when *Euglandina rosea* was brought in to control them, so must have been by then a long-established pest. For a long time Rodrigues was relatively protected against commensal invaders by supply ships being unable to come alongside, but this was ended when a new pier was built in 1980, and self-introduced house shrews appeared in 1997.

Seychelles

Granitic Islands *(Central Seychelles, excluding Coëtivy, Platte, Dennis & Bird)*

Allegedly Arabic tombs in Silhouette (since mostly lost to the sea, Lionnet 1972), supposedly Arabic inscriptions on North Island, and “an arrow head of hard black wood” found embedded in a large felled *bois blanc Hernandia nymphaeifolia* (Pike 1872), are the only physical indications of apparently pre-European visitors to the granitic Seychelles (though the evidence is lost or of indeterminate origin[17]). A Portuguese ship saw people and a fire ashore in 1503, but did not stop to investigate (McAteer 2001). The first documented landing was by an English ship on North Island and Mahé in 1609 (Lionnet 1972 reprinted John Jourdain’s account). Although pirates

Table 3. Introduction of domestic meat animals 2: Miscellaneous + bees

Island /group	Tenrecs	Guinea-fowl	Tortoises	Giant snails	Honey bees
Comoros	9thC	? [<<1628]	[9thC, not feral .Ex]	10thC	? [<<1615]
Mauritius	1780s	1720s	- [tortoises imported, not feral[15]]	1770s	? [<<1768]
Réunion	1801	1714.Ex	- [“]	1780s	1666
Rodrigues	-	c1805.Ex	-	?1920s [<1960]	? [<<1914]
Granitic Seychelles	c1880	1787.Ex	- [“[16]]	<1838	?
Aldabra	-	-	[native species survives]	-	-

15 Native Mascarene tortoises *Cylindraspis* spp. are long extinct on all three islands. There are currently conservation-related feral populations of *Dipsochelys dussumieri* and *Astrochelys radiata* on Mauritian offshore islets (Griffiths et al. 2010)

16 Native Seychelles tortoises *D. dussumieri* subspp. are extinct in the wild. Conservation-related feral populations of Aldabran *D. dussumieri* have been established on several islands (Gerlach 2007).

17 In addition Newton (1867) was told of Arabic inscriptions on the hill on Félicité, but failed to find them himself. In an unpublished study the Silhouette graves were carbon-dated to 200 years old (c.1800) (J. Gerlach in litt. 2010), and, though apparently Muslim (perhaps ship’s crew or slaves), thus post-date European colonisation. The ‘Arabic’ inscriptions on North Island consist of ‘geometrical engravings’ but no script (L. Davolls to J. Gerlach in litt. 2010).

are said to have used the islands in the interim (e.g. Bradley 1940, McAteer 2000, 2001[18]), and artefacts on Frigate have been ascribed to them (Gardiner 1907), it was not until 1742 that there was another documented visit; after that there were several expeditions from Mauritius, but the islands were not settled until 1770 (Mahé & islets) and 1785 (Praslin) (Fauvel 1909, Lionnet 1972, McAteer 2001). As late as 1821 settlement had only extended to La Digue and Silhouette (Moresby 1842). Further islands were settled gradually over the next few decades; the larger granitics were all peopled by 1867 (Newton 1867, Wright 1868). Mahé is by far the best documented island - the timing arrival of commensals (and even humans) is often unclear on the smaller islands of the group. Eighteenth century information is from Fauvel (1909) unless otherwise stated; Gerlach (1995) reviewed 18th century observations, but confined his material to the native fauna.

Some time after 1742 goats were released, and by 1768 they were common on Mahé, though a release in 1768 (Lionnet 1984a) on Praslin failed; the animals were thought to have been eaten by the then abundant crocodiles *Crocodilus porosus*[19]. Further introductions occurred soon after the first settlement - initially on Mahé pigs and cattle: pigs were already wild in 1773, and cattle by 1785; these feral populations were thriving in 1787 (Malavois *in* Fauvel 1909), but had disappeared by the mid-19th century (no mention in Newton 1867, Pike 1872). Escaped cattle established a feral group on Felicité in 1962 (Racey & Nicoll 1984), culled in the late 1980s (Hill *et al.* 2002; still present according to Gerlach 2007), and also on North (eliminated in 2002, Gerlach 2007).

By 1773 there were ship rats on Mahé, and by 1787 they were reportedly widespread on 'nearly all the islands of the archipelago' (Malavois, in Fauvel 1909), though a few of the smaller islands (e.g. Cousin, Cousine, Aride) have always remained rat free (Cheke 1984), as was Bird until 1967 (Racey & Nicoll 1984), and Frigate until 1995 (Thorsen 2000). Norway rats did not reach the islands until very recently. None were found during trapping on Mahé and Praslin in 1976-7 (Racey & Nicoll 1984), and although they probably arrived in the late 1970s (Gérard Rocamora *in litt.*) or the 1980s (Hill *et al.* 2003), they were not reported until 1994 when they were well established on Mahé (Meyer, cited in Hill *et al.* 2003). They are now present on Mahé (and offshore Anonyme) and Praslin, having invaded and been eliminated on Conception and Frigate (Thorsen 2000, Hill *et al.* 2003, Gerlach 2007, Rocamora *et al.* in prep.). Ship rats

18 There is only one reference to the Seychelles in Rogoziński's recent (2000) study of Indian Ocean piracy (1680s-1720s), in which it is emphasized that the Seychelles's prime pirate suspect Olivier La Buse never went there! The Comoros, Réunion, Mauritius and the Maldives feature frequently in addition to the pirate base on Ile Sainte-Marie, Madagascar. However McAteer (2000, 2001) and various websites tell of coffins found on Mahé and chests and tombs on Frigate with characteristics of pirate burial and activity, but there is a shortage of traceable references. However if pirates had frequented the islands they would surely have discovered the then extremely rare and valuable coco-de-mer nut (*Lodoicea maldivica*), and marketed it, but there is no evidence of this - until Frenchmen based in Mauritius did precisely that from 1769 onwards (Lionnet 1970).

19 The now extinct crocodiles have generally been referred in the literature as *C. niloticus* of African origin, but Gerlach & Canning (1994) examined skulls from the Seychelles and demonstrated they were in fact the Indo-Australasian *C. porosus*.

have been eliminated on North Is (Rocamora *et al.* in prep.), and also from the low islands of Bird and Denis (Gerlach 2007). Ship rats may never have been present on Conception (Rocamora *in litt.*), hence the abundant survival there of the endemic white-eye *Zosterops modesta*.

Feral cats were already a nuisance to domestic chickens and hatchling tortoises on Mahé and Praslin in 1787; by 1867 they (and rats) abounded on Mahé, Praslin, La Digue and Félicité, Newton (1867) commenting on the scarcity of birds on the last compared to (then) cat- and rat-free Marianne nearby. Cats are currently feral on Mahé, Thérèse, Silhouette, Praslin, and La Digue (Gerlach 2007); their establishment on Silhouette appears recent, as the wide-ranging cats there were said to be still domestic in the mid-1990s (Gerlach *et al.* 1997). Frigate was cat-free until the 1950s, when domestic animals went feral; this population was finally eliminated in 1981-2 to protect the endemic magpie-robins *Copsychus sechellarum* (Watson *et al.* 1992); they have also been eradicated from Aride and Cousine (Gerlach 2007). Newton (1867) reported feral dogs on Mahé; although neither Lionnet (1984b) nor Racey & Nicoll (1984) regarded the numerous stray dogs as truly feral, Gerlach (2007) reported dogs as feral on Mahé, Thérèse, Praslin and La Digue; domestic dogs have been present since the beginnings of settlement. In 1787 chickens, guinea fowl, goats and sheep were free-ranging on St. Anne Island off Mahé; in 1867 there were feral chickens on Félicité (Newton 1867). Unlike on other islands under discussion, there was no general establishment of feral guinea-fowl in the Seychelles. Tenrecs, apparently brought from Réunion around 1882 (Lionnet 1984b), are present only on Mahé (+ satellites Anonyme & Thérèse) and Praslin (Gerlach 2007). Deer brought from Mauritius were feral on Silhouette during the 19th century (dates unspecified; doubted by Gerlach 2007), and until the 1950s on Frigate (Lionnet 1984b). Giant snails, initially *A. fulica*, were first reported in 1838 (Dufo 1840, Mead 1961) presumably on Mahé, and were already a pest by 1859 (Clark 1859: cvi). Both species were present in the 1930s on Mahé, Praslin and Silhouette (Dupont 1935), and have since spread to most of the granitic islands (Gerlach 1987, 2006b). The dates mice, house geckos, and honey bees[20] arrived are apparently not known. Mice are present on surprisingly few of the islands (Mahé, Silhouette, Praslin, Aride, Frigate and Bird; Gerlach 2006a, 2007). Stump-toed Geckos *Gehyra mutilata* are known from the late 1880s (locality unknown), but found in 1905 on Mahé; now present on almost all islands (Gerlach 2007, Rocha *et al.* 2010b). *Hemidactylus mercatorius* dates from 1905 on Mahé, though not seen again until 1995; it had spread to Frigate by 2002. *H. frenatus* was first found only in 1992 in the granitics (Gerlach 2007; still only on Mahé, Rocha *et al.* 2010), but it is possibly native (Cheke 1984) by drift (or introduced off shipwrecks) on many of the low islands. Rabbits *Oryctolagus cuniculu*s were probably brought in as domestic food animals early on, but information is lacking; they are currently feral only on the tiny islets of Mammelles, Chauves-Souris & Recif. After native animals were

20 Crane (1999) claimed that bees were recorded in 1768, citing Bernardin (1773) who was in fact writing about Mauritius. There were bees reported in 1768, but the abeilles reported and described by the Marion Dufresne expedition of that year were not honey bees but native solitary bees of the genus *Megachile* (Lionnet 1984a).

reduced to a handful (currently captive-bred, e.g. Gerlach 2007), Aldabra tortoises were imported for food during the 19th century (Moresby 1842, Mondini 1990), and in addition to penned animals, feral populations have existed at various times on Curieuse (Stoddart & Peake 1979, Hambler 1994), Frigate and Cousin (pers.obs. 1970s, Bour 1984). Feral Pigeons are a recent arrival; birds established on Frigate in the 1970s may have been the source of the current population on Mahé, Praslin, La Digue and Silhouette (Skerret *et al.* 2001). The current distribution of vertebrates across all the islands, including introductions, are tabulated in Gerlach (2006a) and more fully discussed by Gerlach (2007); the impact of human activities on the islands was summarised in Stoddart (1984b).

Aldabra group

One of the world's largest atolls, Aldabra first joins history as 'Al-Hadra' (and variants) on early 16th century Portuguese maps (e.g. Skerrett & Mole 1995); however as the name is clearly Arabic, the Portuguese were borrowing from previous Arabian knowledge, and a probably Islamic sherd has been found (Stoddart 1971). Apart from the sherd[21], there is no evidence of any landing prior to 1742, when Lazare Picault made landfall there[22] on a rather tortuous journey to the Seychelles from Mauritius (Fauvel 1909, Skerrett & Mole 1995). As an island without surface fresh water[23], Aldabra was unsuitable for settlement, and served human interests solely as a source of tortoises, turtle and fish on short term visits over the next 135 odd years until the Seychelles authorities granted a concession in 1888, since which time, with some breaks, small numbers (never more than 200) people have lived there, mostly on Ile Picard (Stoddart 1971, Skerrett & Mole 1995) - recently only a handful looking after what has been since 1982 a World Heritage nature reserve. There are four main island around the lagoon rim: Picard (=West Is.), Polymnie, Malabar (=Middle Is.) and Grande Terre (=South Is.).

As on other uninhabited islands, goats were released on Aldabra to provide a food supply for temporary visitors, though here this did not happen until the late 19th century,

Table 4. Introduction of 'camp followers'.

Island / group	Ship rat	Norway rat	House mouse	House shrew	House crow	House geckos
Comoros	<9thC	-	?	? [<19thC G.C. only. Ex]	- [pied crows native]	?
Mauritius	<1598	c1735	<1750	c1765	c1900	<1770
Réunion	c1674	c1735	<1754	1730s.Ex + 1860s	2004 ?Ex	?[<<1801]
Rodrigues	<1691	? [<1874]	<1795	1997	-	<<1860
Granitic Seychelles	<1773	1970s	?	-	1970 ?Ex	? [<<1885]
Aldabra	<1890	-	-	-	- [pied crows native]	1970s

21 Some undateable stone enclosures could be pre-European (Stoddart 1971).

22 Picault thought he was on 'Juan de Nove' (the then name for Farquhar) but from his description it is clear he was on Aldabra.

23 A fresh water well was eventually dug in the 19th century at Takamaka (first reported by F. Rivers in 1878, see Diamond 1981).

the animals being first reported in 1878, already on more than one of the atoll's islands (Stoddart 1981). Although long known on Picard and Grande Terre, the first record from Malabar was in 1953 (Prosperi 1957[24]); goats were eradicated from Picard and Malabar islands in 1993-5 and much reduced on Grande Terre (Rainbolt & Coblentz 1999), where they have since increased (Wanless n.d.). A report in 1878 suggesting that pigs should not be introduced (Skerrett & Mole 1995) was too late, as Rivers, visiting that year, was told that several had been released on Grande Terre 'some years ago' and had 'destroyed many young tortoises' before dying out, being all males (Diamond 1981). Ship rats were abundant (at least on Picard) in 1890 (Spurs 1892), and were 'spread over the whole atoll' by 1908 (Fryer 1911); they are currently found throughout (Stoddart 1971); records of *R. norvegicus* are in error (*ibid*.). Cats were recorded in on Grande Terre in 1892 and 1908-9, apparently introduced c.1890 by James Spurs for rat control. By the 1960s they were also on Malabar, Picard (Stoddart 1971) and in 1977 on Polymnie (Racey & Nicoll 1984), but are now common only on Grande Terre (which has some freshwater pools), sporadic on Malabar, and gone from Picard and Polymnie (Wanless et al. 2002). A few feral dogs on Grande Terre in the late 1960s subsequently disappeared (Racey & Nicoll 1984). The facultative house gecko *Hemidactylus mercatorius* is native (as on the neighbouring atolls), but *Gehyra mutilata* appeared in the 1970s (Cheke 1984), presumably through the increased activity of biological researchers (!), but may not have become fully established until 2005 (Gerlach 2007). A plan in 1906 to release rabbits, hares and cattle to increase food for settlers (Beamish 1970) was fortunately not carried out.

The other islands of the group, with far less land area, held fewer native vertebrates. Like Aldabra, they are dry, lacking in surface fresh water and hostile to human habitation; drinking water can only come from rain-water catchment. Although still only visited sporadically by turtle fishermen as late as 1878 (Diamond 1981), Assumption (from 1908) and Astove (from before 1927[25]) later supported massive guano extraction industries for many years, whose effects wiped out most of the native vertebrates through almost complete removal of the vegetation, especially on Assumption (Dupont 1935, Bradley 1940, Stoddart *et al.* 1970, Bayne *et al.* 1970b, Staub 1993).

First visited by Nicolas de Morphey in 1756 (Fauvel 1909), Assumption was not settled until 1908 (Stoddart *et al.* 1970); it is the only island in the group which still has a permanent settlement (Guébourg 1999). In 1878, goats, said to have been introduced in 1867, numbered 5-600 (Diamond 1981, Stoddart 1981); they thrived for decades (*ibid.*), but were thought by Roger Gaymer to be extinct in 1964, though some were said by locals to survive in 1967 (Stoddart *et al.* 1970), though they are now gone (Gerlach 2007). Rats, arrival date unknown, were abundant in 1906 (Nicoll 1908). As on Aldabra, Dupont wanted to add hares and rabbits in 1907 (Stoddart *et al.* 1970). Dogs, cats and chickens (apparently domestic) were seen in 1967 (*ibid.*); by 1986 only cats remained (Roberts 1986; not mentioned by Gerlach 2007). A pair of Feral Pigeons

24 Prior to subsequent confirmation, Stoddart & Wright (1967) doubted Prosperi's record, as well they might, as his book is full of egregious errors (see e.g. Benson 1960: 7-8).

released 1990-91 increased to 69, but were eliminated in 1996 (Skerrett 1994, Skerrett *et al.* 2001)

Astove is said to have hosted survivors from a Portuguese shipwreck in the eighteenth century for 30-40 years; evidence of later wrecks can still be seen (Bayne *et al.* 1970b, from which the rest of this section is taken). It was then scarcely visited until settled intermittently by a few labourers and fishermen from 1895. There was no major impact until phosphate mining began in the 1920s; the island was then continuously inhabited until abandoned in 1978 or a little after (Ron Gerlach *in litt.*[26]). Rats, perhaps from the Portuguese ship, were abundant in 1895; pigs and chickens, brought in soon after settlement, were described as 'semi-wild' in 1960 (Piggott 1969); domestic cattle, ducks and turkeys were added in the 1960s. Pigs left when the settlement was abandoned have gone fully feral (Mortimer *et al.* 1996, Gerlach 2007). No goats or cats were released here.

Like the other atolls, Cosmoledo was irregularly visited for fish and turtle, but never permanently settled, although a small habitation based on Menai existed from the early 1890s (Bayne *et al.* 1970a) until abandoned in 1992 (Rocamora *et al.* 2003). There are 8 main and several smaller islands on the rim of this large atoll. Goats were present on Menai in 1878 (Diamond 1981, Stoddart 1981) - even then in poor condition due to drought; they thrived briefly in the 1890s, but had died out by the 1960s (Bayne *et al.* 1970a[27]). Rats were reported abundant on Menai in 1901 (*ibid.*) as they still are (Rocamora *et al.* 2003), and also reached Wizard (=Grand Ile) and Grand Polyte (*ibid.*); they were eradicated from Grande Ile and both Polytes in 2005-7 (Rocamora in litt.). Rabbits released c1906 on South Is (=Sud-Ouest) (Bayne *et al.* 1970) are still present in small numbers (Rocamora *et al.* 2003). Cats, first reported in 1968 on Wizard, were still evident in 1999 (*ibid.*).

Table 5. Intentional introduction of other common commensals (miscellaneous).

Island /group	**Cats**	**Civet**	**Lemurs *Eulemur* spp. [L] / Monkeys *Macaca fascicularis* [M]**
Comoros	9thC	?[ancient]	9thC [L] [as food]
Mauritius	1680s	-	1602 [M] [?unwanted pets]
Réunion	1680s	-	?1820s [L] [?escaped pets].Ex
Rodrigues	1740s	-	-
Granitic Seychelles	<1787	-	-
Aldabra	c1890	-	-

25 Data for guano extraction at Astove appear to exist only from 1927 (e.g. Bayne et al. 1970, Stoddart 1984b), but probably began several years earlier.

26 There appears to be no published information on exactly when the Astove settlement was abandoned, the nearest being 'in the 1980s' on Wikipedia!

27 Bayne (et al. 1970) and Racey & Nicoll (1984) claimed that Piggott had reported goats on North Is. In 1961; I have not seen the original 1961 typescript report, but there is no mention of goats anywhere on Cosmoledo in the published version (Piggott 1969). The presence of feral pigs was claimed in relation to turtle conservation in 1995 (Mortimer et al. 1996), but presumably in error as there is no other reports of pigs (tame or wild) on the atoll.

Mice[28], honey bees and giant snails appear to be absent from the Aldabra islands.

Geographical origins of commensals

While on islands other than the Comoros we have fairly good records of the arrival times of commensals, history does not always indicate their places of origin.

Rodents & shrews

Mauritian ship rats *Rattus rattus* have 42 chromosomes, but this appears to be a local mutation derived from 38 chromosome 'Oceanian' stock (Baverstock *et al.* 1983, Thiele *et al.* 1997), possibly indicating a very small founding population, but whether from Madagascar or South Asia is not clear. On Madagascar the rats have standard Oceanian 2n=38 karyotypes (Duplantier *et al.* 2003, Fuller & Boivin 2009); the Oceanian type is native to southern India and Ceylon. The question of whether they came direct across the ocean or via East Africa (Fuller & Boivin 2009), has been resolved by DNA studies (Tollenaere *et al.* 2009) which confirm that rats in Madagascar share haplotypes with Indian and Arabia, and they may have colonized once only, long ago, by animals originating in Oman, via East Africa. Grande Comore appears to have been colonized anciently from East Africa independently of Madagascar. The dates calculated by Tollenaere *et al.* (2009) from mutation rates for the rats reaching Madagascar and Grande Comore (c3000 yr BP) precede known times of human contact, so should probably, as they themselves suggest, be treated cautiously. The oldest attested dates for Madagascar are 11thC (Goodman *et al.* 2003), later (as with mice) than for any of the Comoros, which must reflect lack of suitable archaeological records, as the DNA clearly shows that Mayotte acquired its animals from Madagascar; rats there are grey-brown (photo in Louette 1999: 53), as they are in Madagascar (photo in Glaw & Vences 2007). Réunion animals (Tollenaere *et al.* 2009) have a different origin, probably Europe - their pelage is predominantly blackish (as it is in Mauritius, pers.obs.). Rats from Rodrigues and Seychelles have yet to be studied in detail, but in Rodrigues brown morphs predominate (Cheke & Hume 2008: 350, note 464), as they do in the Seychelles (Racey & Nicoll 1984, Hill *et al.* 2003, Gerlach 2007) - which in both cases is odd if the rats came, as presumed, from Mauritius; likewise Aldabran rats are mostly the white-bellied brown form *frugivorus*, grey-bellied *alexandrinus* also occur (Racey & Nicoll 1984). Both house mice *Mus musculus* and house shrews *Suncus murinus* in Madagascar have been related to arriving via Arabian trade routes (Hutterer & Tranier 1990, Duplantier et al. 2002). House mice in Yemen have been separated as *Mus (musculus) gentilulus*, and it appears the Malagasy population is descended from a single colonisation of the Yemeni line (Duplantier & Duchemin 2003, Fuller & Boivin 2009); Comorian mice are likely to be from the same source, possibly via Madagascar. Given that the first European colonists frequently visited Madagascar and were busy

28 Keller (1901), citing H. Schinz, included mice amongst introductions on Aldabra, but as no one else recorded them this is presumably an example of the common 'rats & mice' error, where the presence of one is thought to imply the other.

trading throughout South Asia and the Sunda islands ('East Indies'), both mice and shrews could have arrived in the Mascarenes from either Madagascar or Asia, or, in the case of mice, directly from Europe. In a now rather old DNA study (Yonekawa *et al.* 1981): Mauritian and Seychelles mice were placed phenotypically and genetically with the western European *M. m. domesticus*, with some evidence of Asian introgression. Rats and mice in the Seychelles probably arrived from Mauritius. Shrews in Mauritius were included in a study by Yamagata *et al.* (1995), who found they were very close to mainland Malaysian specimens, which in turn clustered with those from Indonesia, suggesting a source (given the arrival date) from European trade in the East Indies; however they did not includes any Malagasy or African-Arabian animals in their samples.

Ungulates

Goats and sheep in the Comoros probably came from Africa, as they are not attested earlier in Madagascar, though the cattle could have been of Asian origin (carried by Austronesians). Since domestic pigs on Pemba were introduced by the Portuguese (Walsh 2007), no archaeological evidence exists of pre-European domestic pigs in East Africa (Blench 2000), and only bush pigs were introduced early to Madagascar (and even there archaeological evidence is lacking: Goodman *et al.* 2003), it suggests the pig remains found in the 9thC midden on Grande Comore, although tentatively identified as *Sus scrofa* by Wright (1984), probably came from a bush pig. It seems unlikely that there was a continuous presence of feral pigs of any kind, and that if there was a pre-19th century population on Mayotte, it came from a later introduction.

Goats in the Mascarenes are presumed to have come from Europe, transported later thence to the Seychelles from Mauritius and to Rodrigues from (probably) Réunion (all Mascarene data from Cheke & Hume 2008). However both the animals thought to have been released by the Portuguese, and the further ones from Thomas Herbert, in Réunion, as also Dutch release in Mauritius, could have originated in the East Indies. Cattle in Réunion are known to have originated in Madagascar, but the initial release in Mauritius was on an outward journey from Holland (Moree 1998), hence the animals may have been European; further animals, from Madagascar, were sent for, but (*contra* Cheke & Hume 2008) the *Concord* failed in that mission due to storms (Barnwell 1948:14-15). Madagascar was, however, a major source of domestic cattle for the Mascarenes in the 18th and 19th centuries. Pigs were released in Mauritius at the same time as cattle, so presumably also of European origin, while for Réunion it is likely that Thomas Herbert (1634) acquired pigs (and goats) in India[29] - Pring (Kerr 1824, vol.9) was able to get "twenty hogs" in Masulipatnam (=Machilipatnam = Bandar) on the east coast in 1619. For Mauritius at least, where feral pigs remain common, their origin should be easily found using DNA, given the markers known for different centres of domestication (Larson *et al.* 2005, Luetkemeier *et al.* 2010). The deer in Mauritius came

29 He mentioned unexpectedly eating pork with the British factor in Isfahan (while pointing out that pigs & other 'unclean' animals were banned in Persia), and as a product of Ceylon - but nothing about collecting such livestock en route.

from Java. All ungulates briefly feral in 18th century Seychelles were brought from Mauritius (Fauvel 1909), as were pigs and cattle in Rodrigues.

House geckos

House geckos in the Mascarenes first appeared in times of active trade with India and the East Indies; all are Asian species, *Gehyra mutilata* and *Hemidactylus* spp. with DNA identical or very close to Asian mainland or Sri Lankan populations (Rocha *et al.* 2009, Vences *et al.* 2004); however it appears that the Mauritian and Réunion populations of *H. frenatus* have different mainland origins (Vences *et al.* 2004, fig.1). From Mauritius they then reached Rodrigues and probably the granitic Seychelles, and Aldabra (*Gehyra* only) from the Seychelles. However two clearly differentiated DNA lineages of *Hemidactylus frenatus* occur in the Seychelles, one occurring on the low islands (+Mahé), the other only on Mahé (Rocha *et al.* 2010a), suggesting two invasions, possible long separated in time - the low island DNA shows affinities with Ceylon and Burma, the Mahé-only animals with Réunion (and, oddly, the Andamans[30]). This would correspond to an early invasion (natural drift or via pre-European voyagers) to originally uninhabited low islands (Cheke 1984; Poivre, Desroches & Bird sampled for DNA), recently carried to Mahé, and a later very recent influx from the Mascarenes. *H. mercatorius*, native on the southern atolls occurs commensally on Mahé in low numbers, apparently a recent import (1995, Gerlach 2007[31]) from East Africa or Mayotte (Rocha *et al.* 2010a). The situation in the Comoros is even more complex (Rocha *et al.* 2005, 2010a; Vences *et al.* 2004): two species, *Hemidactylus platycephalus* and *H. mercatorius* probably colonised naturally from East Africa (Rocha *et al.* 2010), but both also show signs in their DNA of additional recent human-mediated transport[32] - *mercatorius* from Madagascar, and *platycephalus* from Mozambique. *H. brookii* (Anjouan & Moheli only), as in the Mascarenes, is an introduction, haplotypes being closest to an animal from Réunion (from which the islands were formerly administered), while *H. frenatus* individuals are close to those from Madagascar but not the Mascarenes. They are thus likely to have been introduced to the Comoros from Madagascar, but the origin of the Malagasy animals is unclear, as these animals have a third haplotype group intermediate between but unlike those in either the Seychelles low islands or the Mascarenes, and without (so far) clear links to continental lineages (Fig.5 in Rocha *et al.* 2010a, who did not interpret this pattern[33]). Note that Louette *et al.* (2004) retained, with some reservations, an older classification that did not distinguish between *H. platycephalus, mercatorius* and (extralimital) *mabouia.*

30 Although Indian Ocean Islands (apart from the Maldives & Chagos) were well sampled, continental areas and Indonesia unfortunately were not, so source areas of the lineages are not closely identified.

31 There is also a record from 1905, but it appears to have died out in the interim (Gerlach 2007).

32 Both species are facultative commensals, and mercatorius is frequent on the Aldabra group (all four atolls) in the almost complete absence of human activity, having colonized naturally from Madagascar (Rocha et al. 2010a); see Gerlach (2007) for distribution on other low atolls.

33 One individual from Réunion groups with the Malagasy/Comoros examples, but its haplotype is nevertheless separated from them by 6 substitutions.

Miscellaneous commensals

Cats in the Comoros and Madagascar must have originated in Africa, as on both domestic and feral cats pre-date European contact (Wright 1984, Goodman *et al.* 2003). In the Mascarenes (and hence the Seychelles) feral cats descend from European imports intended to control rats. Comorian civets, as mentioned above, come from India, while Mauritian monkeys hail from Sumatra or Java. Lemurs and tenrecs are endemic to Madagascar, so must have originated there. Guinea fowl are African in origin, though feral populations in any or all the islands (except perhaps the Comoros) could have come, as in Mauritius, from introduced populations in Madagascar. In the Mascarenes and Seychelles, they survive wild only in Mauritius, possibly (like many game birds) subject to repeated introductions. Honey bees in the Mascarenes (and hence the Seychelles) were originally all *A. m. unicolor* from Madagascar (e.g. Smith 1879), though other breeds have been introduced since (e.g. Staub 1993). The giant snails *Achatina fulica* and *A. immaculata* (=*panthera*) are native to East Africa, but introduced to Madagascar (Paulian 1961) and thence to Réunion and Mauritius, then from Mauritius to Rodrigues and the Seychelles; in the Comoros they may have come directly from Africa. There seems to be no information on when they reached Madagascar (Paulian 1961, Mead 1961, Pearce 2003).

One commensal, a late arrival not discussed above, arrives by hitching rides on ships - unlike rats, mice and house-shrews that live on board, house crows *Corvus splendens* from India and Sri Lanka use ships facultatively for scavenging, and sometimes travel with them to their next port. They have spread round much of the Indian Ocean this way, appearing in Mauritius around 1900, though much more recently in the Seychelles [1970] and Réunion [2004] (Cheke 2008). The presence of native pied crows *C. alba* may have kept them out of the Comoros and Aldabra (and Madagascar), though they have successfully invaded East African coastal ports (Lever 2005).

Consequences

The significance of these introductions is of course their effects on the pre-human ecology. These are outside the scope of this paper, except that is appropriate to recall the major issues; the following summary is taken from Cheke & Hume's (2008) review (where further references can be found), unless otherwise mentioned.

Ungulates degrade unadapted vegetation, largely by eating seedlings. **Pigs** root around destroying undergrowth (including tree seedlings) and are serious predators on eggs, and sometimes young, of chelonians and ground-nesting birds. **Cats** eat vulnerable young animals (all groups), flightless birds and naïve adults of flighted birds up to the size of pigeons, and are known to attack and eat lemurs in Madagascar (Brockman *et al.* 2006). They are severe predators of hatchling turtles (e.g. Seabrook 1990 for Aldabra).

The **civet** in the Comoros has been there too long to know what effect it may have had, but it is likely to have altered the ecology in islands previously without native

34 The date mynahs arrived in the Seychelles is disputed, but I see no reason to question Dupont's statement (1930, Lionnet 1984b) that they were released around 1830; the suggestion, echoed by Skerrett et al. (2001), that they were introduced in the 1770s appears to be pure speculation. Newton (1867) was told they had been released on Silhouette some 20 years previously (i.e. c.1847), presumably from birds already on Mahé.

ground predators (apart from land crabs). **Ship rats**, adept climbers, attack birds' nests and any reptiles in a size range too large to hide and too small to eat the rat; **Norway rats** are ground predators on birds' nests and reptiles, and both species are important seed predators, and ship rats keep shrew numbers down. Issues with rats were amply summarised by Atkinson (1985). **Monkeys** impact on birds in the same way as ship rats, but also attack larger species; they also destroy many tree fruits before they can ripen. **House shrews** and **tenrecs** are major predators of native invertebrates and small reptiles. The generalist **cheechak** or common house gecko *Hemidactylus frenatus* is a major competitor to similar-sized native lizards, and eats their hatchlings. **Mice** are not generally seen as a problem in the Indian Ocean, but elsewhere have become serious predators of seabirds. **Giant snails**, when abundant as they often are, consume enormous amounts of vegetation, some endemic island plants being particularly vulnerable. Even such apparently benign animals as **honey bees** compete with day-geckos *Phelsuma* spp. for flower nectar. All this is of course additional to crop damage caused by several of these species.

This is just the commensals - the Indian Ocean islands have also been subjected to a whole gamut of species introduced for sport, biological control or as escaped pets. Of these probably the most insidious is the small Indian mongoose *Herpestes auropunctatus*, introduced in 1900 to Mauritius to control rats (Cheke & Hume 2008), and between 1958 and 1981 to Grande Comore for no known reason (Louette *et al.* 2004); it is devastating for ground nesting birds, though it also keeps shrew and tenrec numbers down. Most of the introduced birds in the Indian Ocean are anthrophilous and have little impact on native ecosystems, but there are exceptions: the Asian Red-whiskered bulbul *Pycnonotus jocosus*, now on Mauritius, Réunion, Assumption, and briefly on Mayotte, attacks nests of small native passerines, predates invertebrates, and, together with the Peking robin *Leiothrix lutea* (Réunion only) spreads seeds of invasive exotic plants through eating their fruits. The Indian Ring-necked parakeet *Psittacula (krameri) manillensis* (Mauritius only) and the common mynah *Acridotheres tristis* (most islands[34]), also from India, competes with native species (Echo parakeets *P. eques*, tropic-birds *Phaethon lepturus*) for nest-holes. In the granitic Seychelles the barn owl *Tyto alba* was introduced in 1949 as a putative rat controller, but only succeeded in decimating endemic microbat *Coleura seychellensis* (e.g. Racey & Nicoll 1984, Paula Senior pers.comm. - but see Gerlach 2009[35]) and fairy terns *Gygis alba* on the larger islands (Skerrett *et al.* 2001); the tern is also susceptible to cats and rats (*ibid*.). The full effects of the recently introduced but rapidly spreading escaped large pet Malagasy gecko *Phelsuma grandis* (Réunion, Mauritius) are yet to be evaluated, but it harasses smaller endemic congeners and probably eats their young. The soft-shelled turtle *Palea steindachneri* from Asia (Mauritius) eats fresh-water life in general including hatchling birds, and the effects of the American red-eared slider *Trachemys scripta* (Réunion,

35 This suggestion is disputed through lack of direct evidence, but the bat's decline coincides with the spread of barn owls (Carl Jones pers. comm.); also a Barn Owl has recently been seen targeting *Coleura* at a roost in Mahé (Paula Senior pers. comm.). However the influence of cats and overgrowing of roost entrances by invasive plants (Gerlach 2009) may also be significant.

birds, and the effects of the American red-eared slider *Trachemys scripta* (Réunion, Mauritius) have yet to be assessed. The Indian wolf snake *Lycodon aulicum* is credited with eliminating endemic skinks on Réunion and Mauritius, and the African guttural toad *Bufo (*sometimes *Amietophrynus*) *gutturalis* is blamed, together with shrews and tenrecs, for devastating native snail populations. In the Mascarenes the mammalian insectivores and toads had done most of the damage before the notorious rosy wolf snail *Euglandina rosea* was introduced to control giant snails, but they are known to annihilate endemic snails elsewhere, mostly where (unlike the Indian Ocean islands) there are no native carnivorous snails (Gerlach 2001). Finally there are a whole gamut of invasive arthropods, some vectors of diseases affecting both humans and wildlife, of which only a few can be mentioned here: the yellow crazy ant *Anoplolepis gracilipes* is a particularly insidious species, present on several of the central Seychelles and at high density on Bird Is., Seychelles (Hill *et al.* 2003b, Gerlach 2004); another highly impactive invasive ant *Pheidole megacephala* is almost everywhere (e.g. Ward 1990, Dorow 1995); the widespread tropical scale insect *Icerya seychellarum* has invaded Aldabra (e.g. Newberry & Hill 1985); and recently the Australian venomous Red-backed spider *Latrodectus hasseltii s*pider has arrived on an offshore nature reserve, Gunner's Quoin, in Mauritius, probably off a yacht on a world cruise (Cole *et al.* 2009)

Game birds (several species), ducks (2 species), swamphens *Porphyrio porphyrio* and black-naped hares introduced into the Mascarenes purely for sport hunting have had little observed impact on the native ecology, and in Mauritius have been drastically reduced in species and numbers by the mongoose. Black-naped hares, brought from Mauritius in the 1920s or 1930s, also occur on Cousin Is., Seychelles (Racey & Nicoll 1984, Lionnet 1984b, Gerlach 2007).

A brief round-up of land vertebrate extinction events

The extinction histories of the different island groups could hardly be more different. In the Comoros, with no early documentation, and until now only one exploratory (and unsuccessful) search for subfossils (Julian Hume pers. comm.), there are no recorded vertebrate extinctions, though it seems likely that there will have been species formerly present that disappeared after humans and commensals arrived, as in Madagascar and elsewhere.

Likewise on Aldabra, but here because human impact has been minimal, there is only one recorded extinction (the warbler *Nesillas aldabrana*; Rocamora & Skerrett 2001), possibly unrelated to humans/commensal activity, though rats could be a factor. However on other islands in this group it is different: Astove and Assumption, which shared many bird species with Aldabra (e.g. Lionnet 1984c, Skerrett *et al.* 2001), have been heavily impacted by guano (phosphate) quarrying, and have lost most of their native wildlife (including seabirds) together with their vegetation cover. Cosmoledo is less damaged, but its land area is quite small, and had fewer species to lose. Aldabra is the only island where a pre-Holocene fauna has been found - in Pleistocene deposits from an inter-glacial period (refs. in Braithwaite 1984).

The granitic Seychelles have not lost many species overall since discovery, largely because there are several islands with different histories of human and commensal

impact; species lost on some islands have survived on others. The extinction rate on Mahé and Praslin is quite high, and Marianne, one of the most bird-rich islands in the mid-19th century, has since been completely deforested, invaded by rats, and lost almost all native species. The animals lost from the archipelago as a whole are the saltwater crocodile (Gerlach & Canning 1994) and three birds, one of which, the 'poule bleu' disappeared before being scientifically identified (Lionnet 1984c). Conservation work in the last four decades has ensured the continued survival of at least four bird species (e.g. Rocamora & Skerrett 2001, Skerrett *et al.* 2001). As in the Comoros only exploratory subfossil investigation has taken place, with so far no discoveries of new species (Hume 2004).

Finally the Mascarenes, which have become, through the Mauritian dodo *Raphus cucullatus*, iconic examples of island extinctions. Extinct subfossil species are still being discovered (Julian Hume pers. comm.), but as of 2008 Mauritius had lost 23 species, Réunion 26 and Rodrigues 25 (Cheke & Hume 2008). Mauritius has done best because of offshore islet refuges, and intensive conservation work since the mid-1970s has helped several species, notably the Mauritius Kestrel *Falco punctatus* whose numbers fell to 4 wild individuals (+ 2 captives) in 1974-5.

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Table 6. A selection of the worst invasive non-commensal vertebrates in the islands (biological control agents = BC)

Island / group	**Mon-goose**	**Barn owl**	**Common Mynah**	**Red-whiskered bulbul**	**Great green day-gecko**	**Wolf Snake**	**Guttural Toad**
reason	*BC - rats*	*BC - rats*	*BC -locusts*	*Esc/freed cage-birds*	*Esc/freed pets*	*carried with cargo*	*BC – mosquitoes*
Comoros	?1960s Grande Comore	[native]	?	1985/6.Ex Mayotte only	-	-	-
Mauritius	1900	-	1762	1892	1980s	1870s	1922
Réunion	-	-	1759	c1970	1994	<1839	1927
Rodrigues	-	-	1820s.Ex <1874	-	-	-	-
Granitic Seychelles	-	1949	c1835	-	-	-	-
Aldabra	-	Ex [native]	-	1985 Assumption only	-	-	-

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Margarodidae (Hemiptera: Insecta) of the Seychelles islands

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Abstract: One species of Margarodidae (Coccoidea; Hemiptera; Insecta) has been recorded from the Seychelles islands: *Icerya seychellarum*. This is a widely introduced species and its original distribution is not known. The earliest records of the species are reviewed and it is concluded that this is probably a Western Indian Ocean species native to Seychelles, the Mascarenes and Madagascar. A second Margarodidae species is described from the Seychelles island of Silhouette. *Gigantococcus dilleniae* is an endemic species with an obligate association with the endemic tree *Dillenia ferruginea*.

Key words: *Icerya, Gigantococcus, Dillenia*

Literature on Seychelles Coccoidea includes only one species of Margarodidae, the cosmopolitan mealy-bug *Icerya seychellarum*. This species is an agricultural pest and is widely introduced and its original distribution is obscure. Here I review the distribution and origins of *I. seychellarum* and describe a new species of Margarodidae endemic to the Seychelles islands.

Icerya seychellarum (Westwood, 1855)

Dorthesia seychellarum Wetwood 1855: 836

Icerya seychellarum Green 1907: 198

Icerya seychellarum was first described in 1855 from a specimen on a cultivated plant originating in Seychelles. Westwood (1855) assumed that the insect had been imported along with the plant, and thus was of Seychelles origin. The next record of the species is from Mauritius, based on a specimen collected sometime before 1867. Subsequently it was recorded in Madagascar (1904) the Philippines (1905), Japan (1907), Africa (1914), the Mascarenes and Comoros (1943) and South America (1946) (Fig. 1a). Since then it has been identified throughout the tropics. The dating of the early samples suggests a Western Indian Ocean origin, and dispersal from the region in the late 1800s to early 1900s. The original Seychelles record cannot be proved to be correct but it is notable that several insect species were described at that time based on specimens found in hot houses, which have subsequently been found in Seychelles (and in some cases this remains the only known locality).

Icerya is a mainly Asian genus, although several species have become pantropical or even cosmopolitan. *I. seychellarum* is related to several other species, forming the '*Icerya seychellarum* group'. These other species are found in India, Sri Lanka, Vietnam and Hong Kong (Fig. 1b). Within the group *I. seychellarum* may be most closely related to *I. crocea* of India, Sri Lanka and Hong Kong. This distribution

suggests that the I. seychellarum group is primarily south-Asian; many Western Indian Ocean insects have affinities to south-Asian species, further supporting the suggestion that *I. seychellarum* may originate from the Indian Ocean. It is difficult to draw any wider comparisons; many of the other coccoids of the Seychelles islands may be introduced, of the 6 probably indigenous species 1 is Australasia, 2 Indo-Pacific, 1 east Asian and 2 occur in Seychelles, India and Sri Lanka. All the apparently endemic coccoids belong to widespread genera.

In Seychelles the first locality records are from 1905 (Green 1907) when it was collected on Mahé, D'Arros, Poivre and Desroches. The lack of other localised records reflects a lack collecting of coccoids until the early 1900s and then only on agricultural estates of Mahé and the Amirantes. It is thought to have colonised Aldabra in 1967,

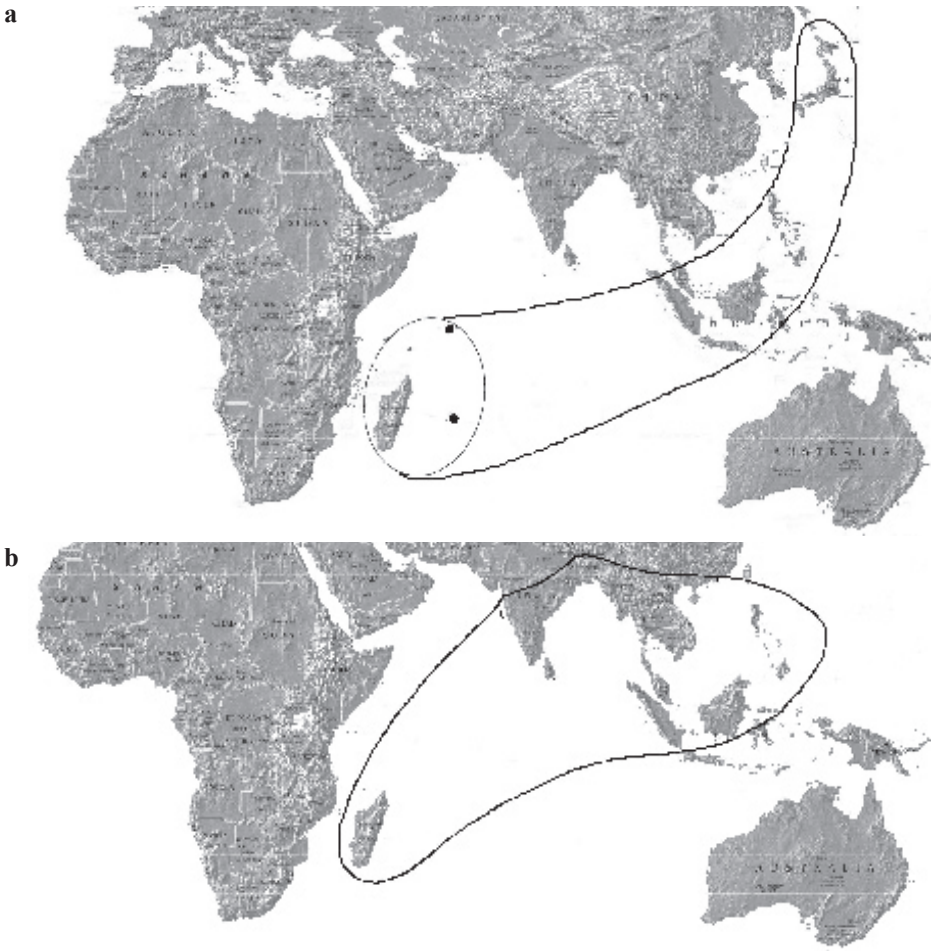

Fig. 1. a) Range of *Icerya seychellarum* prior to 1910. b) Range of '*Icerya seychellarum* group'

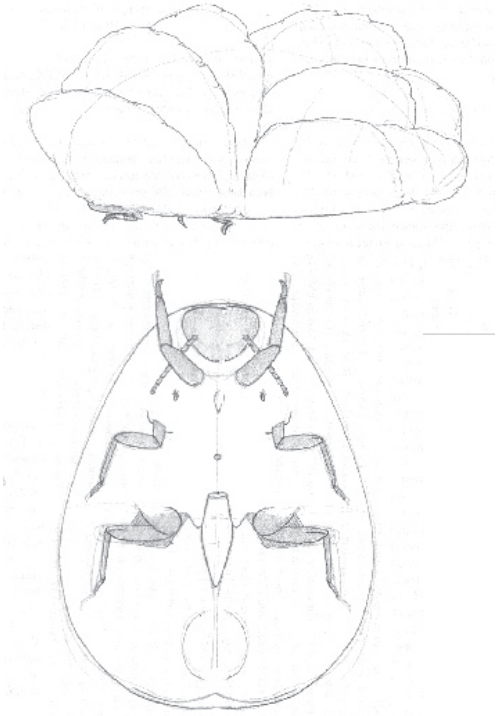

Fig. 2. *Gigantococcus dilleniae*, adult female in lateral and ventral view.. Scale bar 2mm

although similarly no coccoid collections were made on the atoll prior to this date. Thus it can be concluded that by the time coccoids were collected the species was established in the granitics, Amirantes and Aldabra.

***Gigantococcus dilleniae* sp. nov.**

Material examined - 2 females collected Mon Plaisir 15.xii.1993. 1 adult female – Mon Plaisir, Silhouette 13.vii.2000 (det. C. Hodgson). All collected on *Dillenia ferruginea* trunks, Mon Plaisir, Silhouette.

Description: Adult female oval (holotype 8.4 mm long, 5.8 mm wide, widest across abdomen), widest towards posterior; covered with white wax in several rows. Had and thorax region covered by three transverse rows, front half of abdomen with 5 longitudinal rows, posterior half with 4 rows radiating out from centre of abdomen. Intervening spaces with granular wax. Ventral abdomen with a thin layer of white wax. Antennae 9 to 10 segmented; each segment with short hair-like setae. Eyes circular, at base of antennae.

Legs well developed; forelegs shorter than mid- and hind legs. Hair-like setae scattered in groups on derm, not noticeably longer around margin. Compound multilocular pores usually with trilocular centre covering dorsum and margins of ventral

Table 1. Measurements of *Gigantococcus dilleniae,* all 8.x11.2009

Specimen	Length	Width	Height	
Holotype (Hh2009.1)	8.4	5.8	-	
Paratype (Hh2009.2a)	9.1	7.0		
Paratype (Hh2009.2b)	7.7	5.6		
Paratype (Hh2009.3)	11.4	6.4	7.3	female with nymphs

head and thorax and submarginal to marginal ventral abdomen. Simple multilocular pores with trilocular centre scattered on ventromedial head and thorax. Marsupium present, marsupial band forming narrow V-shape with lateral flanges at anterior. Cicatrices not visible. Anal tube surrounded by long hair-like setae; derm around anal opening not sclerotized.Unlike other *Gigantococcus* species the derm does not become sclerotized, even in the largest individuals with the exception of a small area of the abdomen under the posterior femorae.

Nymph: typical for Icerini. Two pairs of wax blocks on thorax and eight pairs of on abdominal segments. Long hair-like setae at apex of abdomen in 3 pairs (typical of *Gigantococcus*). Length 1.2mm. 115 nymphs in one female.

Notes: The *Dillenia ferruginea* trees that are fed on by *Gigantococcus dilleniae* also support I*cerya seychellaru*m, but this latter species only feeds on leaf and flower petioles, not the trunk of the tree.

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Phelsuma **18** (2010); 74-81

Distribution and activity pattern of the Yellow bellied mud turtle *Pelusios castanoides intergularis* Bour 1983 on La Digue, Seychelles

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Abstract: The Yellow bellied mud turtle *Pelusios castanoides intergularis* Bour 1983 on La Digue was investigated within several excursions on the island in December 2004, 2007 and 2008. The main population is located at the Mare Soupape at the west side of the island, however, a second population was found to be present at the water bodies at Grand Anse (east side). On sunny days, activity was restricted to the morning and the late afternoon hours, whereas after rain falls turtles were also active at noon and early afternoon hours. In 2008, a relatively long dry season caused a dramatic decrease in water levels along the island, leading to almost all tributaries of the Mare Soupape drying out and remaining water bodies at Grand Anse were restricted to small areas by the end of the same year. Temporary dry periods will usually not affect freshwater populations on La Digue, however, the drop of water levels seen in the second half of 2008, lasting for longer time periods could result in an additional and permanent habitat loss.

Key words: habitat, distribution, biology, conservation.

Introduction

The central Seychelles islands are inhabited by two endemic subspecies of mud turtles, the Black mud turtle *Pelusios subniger parietalis* Bour 1983 and the Yellow bellied mud turtle *Pelusios castanoides intergularis* Bour 1983. The status of a third species, the Seychelles mud turtle *Pelusios sechellensis* Siebenrock 1906 once thought to live also on these islands remains unclear (it may be extinct: Bour 1983, 1984, Gerlach 2008a).

The populations of the two recent subspecies, especially on the increasingly urbanised main islands of Mahé, Praslin and La Digue decreased dramatically during the past decades mainly due to habitat destruction, fragmentation and pollution (Gerlach 2008a, Gerlach & Canning 2001, Pawlowski & Krämer 2006). For this reason, both freshwater turtle subspecies are considered as "Critically Endangered" (Gerlach & Canning 2001). As a consequence they are included in the NPTS breeding program in order to stabilise populations by the release of juveniles back into the wild (Gerlach 1997, 2002b, 2006, 2008b). Whereas the reproductive rate of the black mud turtle is considered to be good, the breeding success in the second species is low (Pawlowski & Krämer 2010a). Within the central islands only a few sites for the Yellow bellied mud turtle are left more or less undisturbed: The rivers at Anse Intendance on Mahé and the river Mare Soupape on La Digue (Gerlach 2000). The main former habitat on Praslin (Anse Kerlan marsh land), however, seems to be lost forever at least for the Yellow bellied mud turtle due to the construction of a large golf course (Gerlach 2008a, Gerlach & Canning 2001).

During several excursions on La Digue island in December 2004, 2007 and 2008 distribution and the activity pattern of the Yellow bellied mud turtle were

investigated. Furthermore, a second previously unknown, population of this turtle species was found on this island in 2007 (see also Gerlach 2000, 2002a, Gerlach & Canning 2001, Pawlowski & Krämer 2006).

Results

Observations on La Digue

The distribution and activity pattern of the yellow bellied mud turtle on La Digue were observed at various times during the day ranging from early morning (about 8:00 a.m.) until evening (about 6:30 p.m.) at the river Mare Soupape and its tributaries and at the water locations at the Grand Anse. The rivers La Passe, Laporte and La Source Marron along with the water bodies at Anse Cocos were not recently investigated. All observations were made by sight only.

During the time period from December 11-14th, 2007, air temperature was measured using a digital thermometer (Amadigit ad 15 th; -40 – 120 ± 0.1 °C) and weather conditions were also recorded visually.

Actual water situation

The mountains of La Digue which are more or less arranged in south-north direction, separate the island into a broader western and a smaller eastern lowland area. Due to its height of up 333 m (Mont La Digue) rain clouds tend to stick to this mountains releasing their water into the forests along these hills, this being the source of small and medium sized rivers at the west and east sides respectively (Fig. 1). The Mare Soupape with a total length of about 2 km and its tributaries in the western lowland is the biggest river on the island and is known to support a population of the Yellow bellied mud turtle (Gerlach & Canning 2001, Pawlowski & Krämer 2006). The rivers La Passe and Laporte are, in contrast, rather small and do not contain any populations of freshwater turtles to our recent knowledge. However, at the south-east side along Grand Anse, Petit Anse and Anse Cocos a few small rivers formed several fairly large water areas. These were at least partly covered by either Hyacinths *Eichhornia* sp. or Water lettuce *Pistia stratoites*, invasive aquatic plant species growing on the water surface which resulting in shading of the water bodies (Gerlach 2000, Pawlowski & Krämer 2006, 2008).

As all rivers on La Digue are fed by the rain water from the mountain side, the water level in the rivers and ponds are strongly correlated to the dry (April to September) and wet seasons (November to February). However, as the 2008 dry season was very intense in the inner granitic Seychelles islands (including La Digue) river water levels on La Digue dropped dramatically until the end of 2008. In fact, water level at the Mare Soupape and at the river and ponds at the east side were about 1 to 2 m below the levels observed in the years before (2004 and 2007). As a consequence, almost all tributaries of the Mare Soupape and the small rivers La Passe and Laporte at the west side were dried out (Fig 1). In addition, the ponds at the eastside (i.e. at Grand Anse) also almost dried out, so that only small water areas of less than 100 m^2 were remaining (see also satellite pictures at Google-Earth in 2009). However, the status of the river La Source Marron by the end of 2008 remains unclear as it cannot be reached from the land on a regularly travelled route.

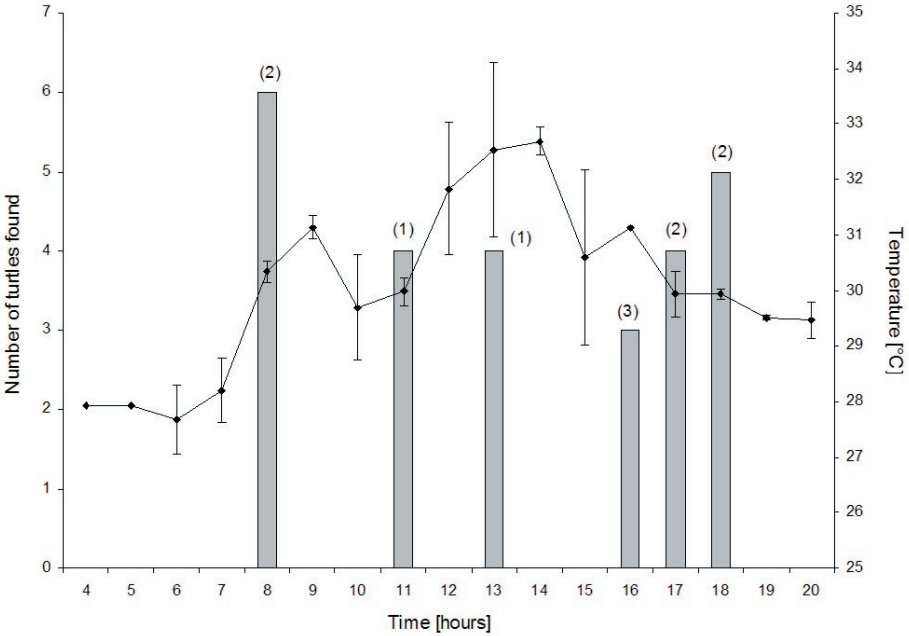

Fig. 1. Activity pattern of adult Yellow bellied mud turtles *Pelusios castanoides intergularis* and corresponding air temperatures (December 2007) on La Digue. Number of observations in brackets.

Observed populations

All turtles observed were adults, no semiadults (5 to < 10 cm carapace length; see Gerlach 2002b for details) or juveniles (approximately 3 to 5 cm carapace length) were detected at either site. At the river Mare Soupape Yellow bellied mud turtles could be observed at various sites of the main river itself and also in its tributaries in December 2004, 2007 and September 2008 (by Sauberer, Fig. 2). In November 2008, no freshwater turtles could be found on La Digue at all by Hofrichter (pers. communication 2009). In December 2008, no turtles could be found along the river Mare Soupape at low water level (approximately 1 m below normal level). The number of turtles found were generally low (1 to 2 specimens with 100 to 200 m) distance, however, at specific sites (feeding places) some sort of agglomeration of turtles took place, were up to 4 or 5 individuals came together (Table 1).

Although the river Mare Soupape was investigated at various times of the day most of the turtles were found active either in the morning or the late afternoon (Fig. 2). During the daytime adults were only found at the shady areas of the Mare Soupape but in the late afternoon, turtles were also located at the non-shaded areas of the river. Only one observation in 2004 shows an activity of these animals in the early afternoon (approximately 1:00 p.m.), however, weather conditions were rather worse in the morning (heavy rain), whereas sunny weather was present at all other observation time periods.

Fig. 2. Water levels and investigated sites (1 – 7) of Yellow bellied mud turtles *Pelusios castanoides intergularis* at La Digue. Left – normal water level; right – water level by the end of 2008 (end of dry season); blue – rivers and other water bodies; red – main roads

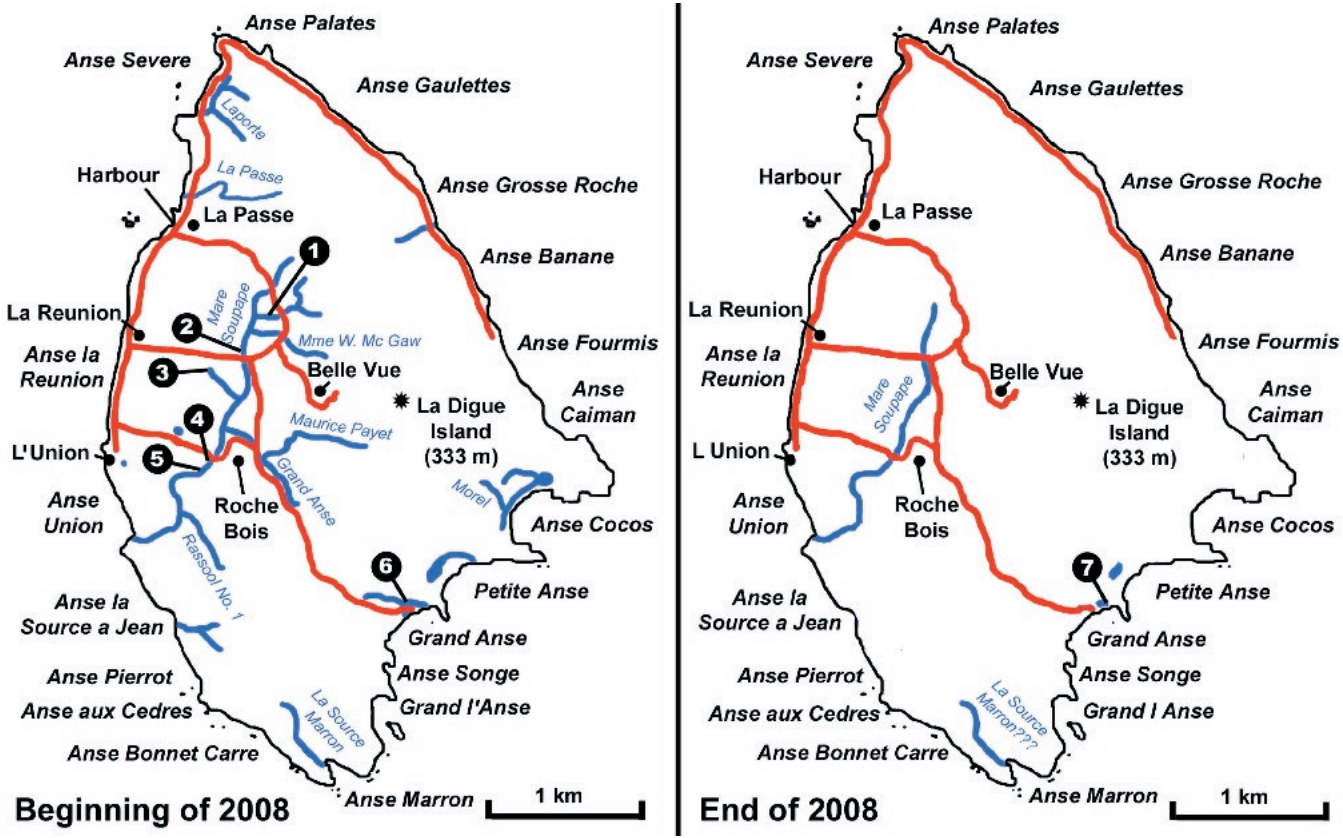

Table 1. Number of observed Yellow bellied mud turtles *Pelusios castanoides intergularis* Bour, 1983 at La Digue

Locality	Date	Approximate time	Number of animals	Site[1]	Comments
Mare Soupape	09.12.04	1:00 p.m.	≥ 4 (adults)	4	Only found at the shady side of the river; however, rain was falling during the morning hours
	11.12.07	4:00 p.m.	1 (adults)	3	Sunny weather
	11.12.07	5:30 p.m.	3 (adults)	5	Sunny weather
	12.12.07	8:00 a.m.	1 (adults)	2	Sunny weather; animals were fed for better visibility
	12.12.07	5:30 p.m.	2 (adults)	4, 5	Sunny weather
	13.12.07	4:00 p.m.	1 (adults)	2	Sunny weather; animals were fed for better visibility
	13.12.07	8:00 a.m.	5 (adults)	2	Sunny weather; animals were fed for better visibility
	14.12.07	11:00 p.m.	4 (adults)	2	Sunny weather; animals were fed for better visibility
	23.09.08	7:00 a.m.[2]	1 (adults)	1	Sunny weather, low water level
	Dec. 08	Various times	0	2 – 5	Sunny weather; low water level
Grand Anse	09.12.04	3:00 p.m.	0	6, 7	Sunny weather in the afternoon; normal water level
	14.12.07	4:00 p.m.	1 (adults)	6	Sunny weather; normal water level
	01-05.12 08	Various times	0	6	Sunny weather; no water remaining
	01.12.08	5:00 p.m.	2 (adults)	7	Sunny weather; less remaining water
	03.12.08	5:00 p.m.	2 (adults)	7	Sunny weather; less remaining water

[1]See Fig. 1 for further details; [2]Observations by Sauberer 2008, pers. comm. 2008.

At Grand Anse, less time was spent observing the water bodies in 2004, recording no turtles at about 3:00 p.m. In contrast, one adult turtle was found at the surface water level at site 7 but disappeared within at short time after its discovery back into the depth of the water. As water levels at Grand Anse dropped dramatically until December 2008, most of the water had already disappeared (probably since summer 2008, as a number of terrestrial plants were already growing in the upper river level). At the low end of the river, only a small water reservoir of about 10 m^2 surface and maximum about 50 cm depth was remaining. No turtles were found during the daytime however, two individuals were present and active at the late afternoon (about 5 to 6:30 p.m.) on several days of observations.

Discussion

The endemic Yellow bellied mud turtle *Pelusios castanoides intergularis* on La Digue is mainly found at the river Mare Soupape and its tributaries along the west side of the island. As several individuals were observed at the water bodies along the Grand Anse (east coast) it can be concluded that there is a second independent population of

that species living on this island. This is in contrast to previous studies, where only few individuals of Black mud turtles *Pelusios subniger parietalis* could be found here (Gerlach 2002b, Gerlach & Canning 2001). On the other hand, the latter species could not be found on La Digue at any time of our investigations.

As the west side of La Digue is rather flat, it is very likely that the freshwater turtles move via muddy or terrestrial areas in order to find new water bodies, especially at times of low water levels within the dry season (Sauberer 2008, pers. comm..; Gerlach 2002b). The water bodies at Grand Anse are embedded in a mountain scenario (up to approx. 200 m), which are rather unlikely to be crossed by turtles coming from the west side of the island.

The distribution pattern of *Pelusios castanoides intergularis* fits mainly with the previous investigations on La Digue and on the other central islands of the Seychelles (more or less shady areas of lowlands rivers and ponds), however, depending on the daytime and weather conditions turtles can be found also at non-shady areas of both the Mare Soupape and at the Grand Anse. Mashes directly connected to the sea contain at least temporarily brackish or pure salt water, are not inhabited by this species.

Overall, under sunny weather conditions turtles were active within the morning or the late afternoon hours only. Similar to the terrestrial Aldabran tortoises *Dipsochelys dussumieri* Gray, 1831, activity pattern changes during daily rain periods (Coe & Swingland 1984, Pawlowski 2008, 2009a, Pawlowski & Krämer 2005a, b).

Actual investigations on the river water situations on La Digue displayed a dramatic drop of the water levels at the Mare Soupape and a loss of water areas and bodies, respectively, which indeed restrict the possible habitat of both *Pelusios castanoides intergularis* and *Pelusios subniger parietalis* to small areas at both the west and the eastside of the island by the end of December 2008. Within the recent discussion on the climatic change and their possible impact on the fresh water turtle situation, it is unlikely that temporarily dry periods will affect the freshwater turtle populations at the Seychelles in the end (i.e. on La Digue), as turtles of the genus *Pelusios* are either able to walk over land to reach new water bodies (Sauberer 2008, Bombi *et al.* 2009, Gerlach 2002b) or being able to rest in the mud for up to several months (Grychta 1999). Furthermore, dry periods or periods of low rain fall also occurred in the past on these islands at regular intervals (see also Gerlach & Canning 2001, Walsh 1984). Observations on captive individuals of both freshwater turtle species indicates that they at least temporarily spend their time hiding in the soil close to the water bodies (Pawlowski 2009b, Pawlowski & Krämer 2006, 2008, 2010a). A similar resting behaviour can also be observed for the North American Diamondback terrapins *Malaclemys terrapin terrapin* Schoepff 1793 and *M. t. centrata* Latreille 1801, a species being restricted to the brackish waters along the east coast (Brennessel 2006, Pawlowski & Krämer 2010b). However, if the low water levels do not be rise back to the normal levels within the wet season, some of the habitats might be lost forever within the following dry season (Spring 2009). Overall, low water levels at the beginning of a new dry period along with an increase in human water consumption due to both population and tourist growth on La Digue will minimise the remaining water resources on this and the other central Seychelles islands like Mahé and Praslin (Pawlowski 2009b,

Pawlowski & Krämer 2009). Thus, sufficient amounts of freshwater might become one of the major issues for this island and subsequently for the freshwater turtles in the future (besides all the other aspects of habitat destruction and pollution). As juveniles or semiadults were either rarely found or totally absent, and as possible nesting sites are still unknown, the threat of an aging population on La Digue, as well as on other central islands, indicates an urgent need for further investigations and conservation. There is no doubt that habitat destruction and pollution due to the increase in urbanisation and cultivation of landscapes are the main reasons for the population decrease in the past decades (Gerlach 2000, Gerlach & Canning 2001, Pawlowski 2009b, Pawlowski & Krämer 2006, 2008). In addition, the introduction of alien land predators such as dogs, cats, rats, tenrecs and possibly Tilapias *Sarotherodon mossambicus* Peters, 1852 (a threat for hatchlings) might contribute to the decline in reproductive success (Gerlach 2002b, Nussbaum 1984). As nesting sites are likely to be located along the rivers, an increase in human wastes and discharges along the rivers will also increase the number of various mangrove crab species, which are known to be a major threat for juvenile turtles (Brennessel 2006, own observations).

Conclusion

Overall, it can be concluded that the population on La Digue is threatened by various causes, which are mainly linked to the urbanisation of the island. Whilst a temporary dry period will not affect the population of freshwater turtles, an extension of habitat loss due to long lasting dry periods together with anthropogenic habitat destruction and pollution will indeed have a deep impact on the future of the fresh-water turtle populations. As a consequence, a rescue plan for this species needs improvement in many levels such as establishment of water saving and cleaning processes (water treatment plants), waste disposal management and of course a better environmental conservation education in order to safe the last remaining habitats of *Pelusios castanoides intergularis* on La Digue and also on the other central islands

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Phelsuma **18** (2010); 82-89

Reproduction in the tree frog *Tachycnemis seychellensis*

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Abstract: Captive breeding of the Seychelles tree frog *Tachycnemis seychellensis* (Hyperoliidae) is reported. The tadpoles of this species are described and compared to those of the only other Seychelles frog to have free-living tadpoles, the Mascarene frog *Ptychadena mascariensis* (Ranidae). Eggs may be laid more than once a year in clumps above water. Embryonic development and hatching occurs out of water, and the fully developed tadpoles fall into the water below the egg mass. The time from hatching to metamorphosis is 45-141 days with a bimodal distribution of metamorphosis dates. Tadpoles feed on detritus. One male started calling at 450 days from metamorphosis (485 days from hatching) having reached 44mm SVL.

Key words: Seychelles, Hyperoliidae

The hyperoliid Seychelles tree frog *Tachycnemis seychellensis* (Duméril & Bibron, 1841) is widely distributed on the Seychelles islands of Mahé, Silhouette, Praslin and La Digue. It is currently classified as Least Concern by the IUCN Red List. Its distribution is reasonably well known but there is little information on the ecology of the species. Some studies of behaviour and diet in anthrophilic situations have been published (Rocamora 2003; Gerlach & Rocamora 2004) as has a brief account of general ecology (Nussbaum 1984). Knowledge of reproductive biology is restricted to descriptions of tadpoles (Boulenger 1882; Drewes 1984; McDairmid & Altig 1999), reports of eggs being laid adjacent to streams where flood-waters may transfer the tadpoles into the water (Nussbaum 1984) and a report of frogs laying 100-500 eggs on aquatic vegetation in standing water or the bottom of pools (Henkel & Schmidt 2000). However, the details of this last account are not known.

In 2008 a pair of tree frogs were collected at La Passe on Silhouette island and maintained in captivity. The female laid eggs on two occasions; both clutches hatched and were successfully reared. This captive breeding is reported here and a description of the tadpoles presented. In addition, for comparative purposes a description is given of the tadpoles of the Mascarene frog *Ptychadena mascariensis*, the only other Seychelles frog with free-living tadpoles.

Captive maintenance of Seychelles tree frogs

Two adult frogs were kept, a female caught on 2nd July 2008 and a male on 31st October 2008. Both were from the La Passe population on Silhouette island. The adults were kept in a glass vivarium measuring (in cm) 60x30 x 40h, with a wooden lid (Fig. 1). The vivarium was filled with water to a depth of 2cm and in this were placed 2 sprouting coconuts. These provided hiding and climbing places for the frogs while the water provided constant moisture. No artificial heating or lighting were provided,

ambient conditions were a temperature range of 22-32ºC and humidity levels of 75-95%. Humidity within the vivarium was not recorded but was probably constantly above 85%. Frogs were fed with burrowing cockroaches (*Pycnoscelus surinamensis*) 3 cockroaches each on most days.

On hatching tadpoles were transferred to a large, shallow aquarium measuring (in cm) 50x100 x 25h. This was filled with 1.5cm of washed sand and 10cm of water. The aquarium was placed at an angle to provide shallow and deep water. Stones were placed in the centre to allow froglets to climb out of the water on metamorphosis. The aquarium was covered with a mosquito mesh screen allowing free-flow of air but preventing escape. Some filamentous algae and dead leaves of *Calophyllum inophyllum* were placed in the water as a possible food source. The algae were never eaten but the leaves were grazed as they blackened and decomposed. Tadpoles were periodically provided with commercial terrapin food pellets (various brands) which were consumed.

On metamorphosis (when they emerged from the water) froglets were transferred to small vivaria (30x20 x 25h) with solid lids. These contained flower pots of soil and plants, standing in 1.5cm of water. Froglets were fed on small insects, mainly *Drosophila* fruit flies. When they reached 20mm snout-vent length (SVL) they were fed small cockroaches under 5mm long.

Reproduction

Amplexus was observed on 29-30th November and most of the first half of December 2008. Oviposition was not observed and tadpoles were first seen on 9th August 2009. By this time they measured an average of 10.2mm total length (body length 3-4mm). A second clutch of eggs was found in October 2009. 148 eggs were laid on a coconut 2cm above the water-line.

Tadpole descriptions – all measurements given in mm.

Ptychadena mascariensis tadpoles (Fig. 2).

Source: Mascarene frog tadpoles were collected from the Grande Riviere at La Passe, Silhouette on 9th July 2008.

Description: Type IV, exotrophic, lentic and benthic tadpoles. Total length 43.2, body length (15.2) 37% of total length; body shape oval, body length 188% of body height (8.0), and body width (10.2) 127% of body height, without constrictions between head and trunk; snout pointed in dorsal and lateral profile; eyes relatively large, dorsolaterally placed; eye diameter 26% of body width at eye level, and 393% of interorbital distance, interorbital distance (4.3) 7% of body with at eye level. Nostrils subcircular, dorsal, slightly elevated, closer to tip of snout than to eye, rostronasal distance 65% of orbitonasal distance; internarial distance (1.4) 7% of interorbital distance. Spiracle sinistral, spiracular tube and opening ventral. Vent tube length 23% of body length; vent opening medial. Tail length 63% of total length, tail height at the base of the tail (5.2) 69% of body height; dorsal and ventral fins well developed, with slightly curved margins; maximum tail height approximately at one third to middle of length, 110% of body height; tail axis straight and tip of tail rounded pointed. Caudal musculature height at base of the tail 59% of body height, caudal musculature width at the base of the tail

64% of body width; myotomes clearly visible.

Oral disc sub-terminal, not visible dorsally; oral disc width 1.4, disc small, about 21% of maximum body width; disc pointed anteriorly; a row of lower marginal papillae and an additional lateral row; no mental gap and rostral gap narrow; intramarginal papillae absent; tooth row formula: 1/2. Beak pointed, serrated

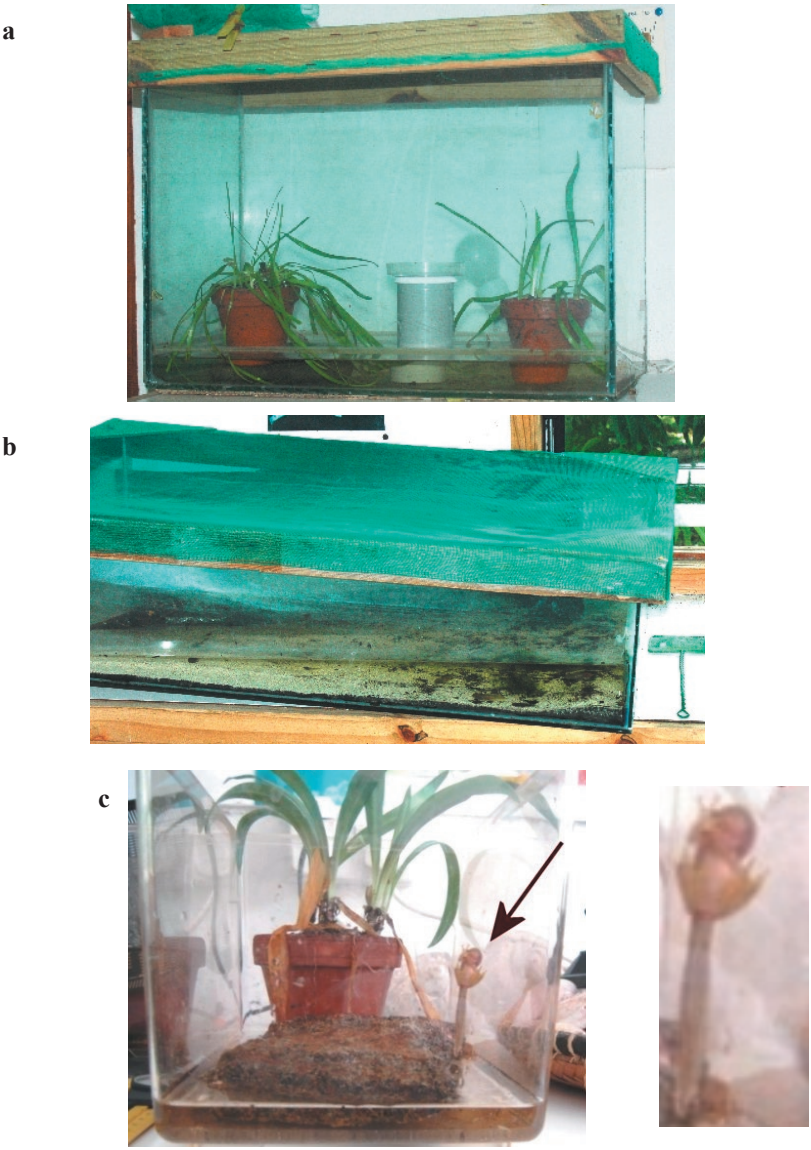

Fig. 1. Captive rearing system. a) Breeding vivarium, b) Tadpole aquarium, c) Juvenile vivarium, arrow shows metamorph with tail, and shown right

Dorsum and lateral body sizes grey, mottled brown; ventral region grey, peribranchial zone paler than abdominal region, abdomen with guanophores; fins transparent with mottled pigmentation; caudal musculature darker with melanophores arranged more densely on fins.
Metamorph: dorsum and lateral body sides ochre with irregular darker patches, a medial dorsal green line developing at metamorphosis; dark pigmentation around nostril; ventral region pale grey, peribranchial zone paler white, abdomen with guanophores; fins transparent with sparse melanophores.

Tachycnemis seychellensis tadpoles (Fig. 2).
Source: tadpoles at various stages of development collected from Grande Riviere, La Passe, Silhouette on 14th July 2008 and captive bred in July and October 2009.
Description: Type IV, exotrophic, lentic and benthic tadpoles. Total length 36.5-44, body length (11.9) 32% of total length; body shape depressed oval, body length 210% of body height (5.9), and body width (7.9) 123% of body height, without constrictions between head and trunk; snout broad, rounded in dorsal and lateral profile; eyes relatively large, dorsolaterally placed; eye diameter 17% of body width at eye level, and 12% of interorbital distance, interorbital distance 72% of body width at eye level; rostro-orbital distance 34% of body length. Nostrils subcircular, dorsal, not elevated, closer to tip of snout than to eye, rostronasal distance 45% of orbitonasal distance; internarial distance 50% of interorbital distance. Spiracle sinistral, spiracular tube and opening ventral. Vent tube length 19% of body length; vent opening dextral. Tail length 68% of total length, tail height at the base of the tail (6.1) 92% of body height; dorsal and ventral fins well developed, with slightly curved margins, dorsal fin originates distal to body, edge waved; maximum tail height approximately 25% of distance from body, 120% of maximum body height; tail axis straight and tip of tail slightly pointed. Caudal musculature height at the base of the tail 72% of body height, caudal musculature width at the base of the tail 40% of body width; myotomes clearly visible.

Oral disc sub-terminal, not visible dorsally; moderately wide, about 25% of maximum body width; disc without angular constrictions; a row of well developed marginal papillae in anterior, posterior and lateral regions; no mental gap present (cited as wide in McDairmid & Altig 1999), narrow rostral gap less than 10% of oral disc width; intramarginal papillae present ventrally; tooth row formula 2/2(1). Upper jaw wide, serrated; lower jaw moderately wide, V-shaped.

Dorsum and lateral body sizes uniformly dark reddish brown; a dark line between eye and nostril; ventral region grey, peribranchial zone paler than abdominal region, abdomen with guanophores; fins transparent with dense mottled pigmentation; caudal musculature dark.
Metamorph: dorsum and lateral body sides uniformly dark brownish green; tail mottled with pale areas. Pale stripe from nostril to eye. Ventral region pale yellowish; toes elongate with distinct toe pads, yellow.

Development: Development patterns shown in Figs 3-5. The smallest tadpole to develop legs had a snout-vent length of 12.0mm; the largest to start developing les was 14.7mm. The smallest with all legs developed was 14.5mm; the normal range was

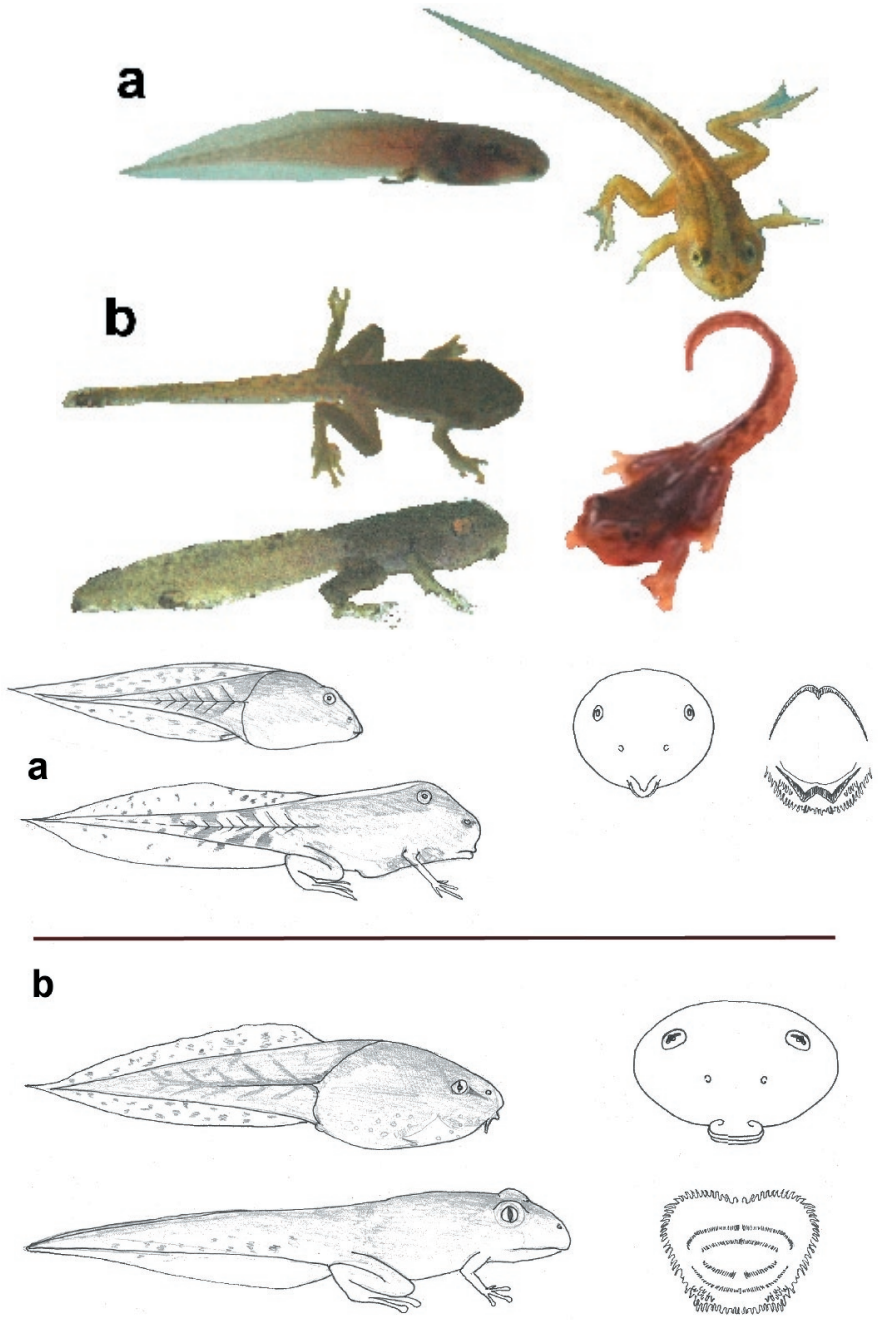

Fig. 2. Tadpole morphology of a) *Ptychadena mascariensis*, b) *Tachycnemis seychellensis*. Drawings on right show tadpole head in anterior view and mouthparts.

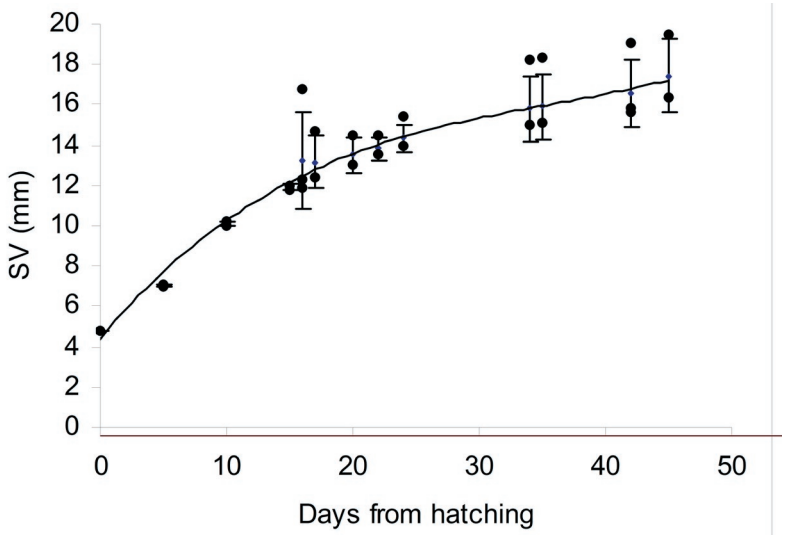

Fig. 3. Growth pattern of the five fastest developing tadpoles from hatching to metamorphosis.

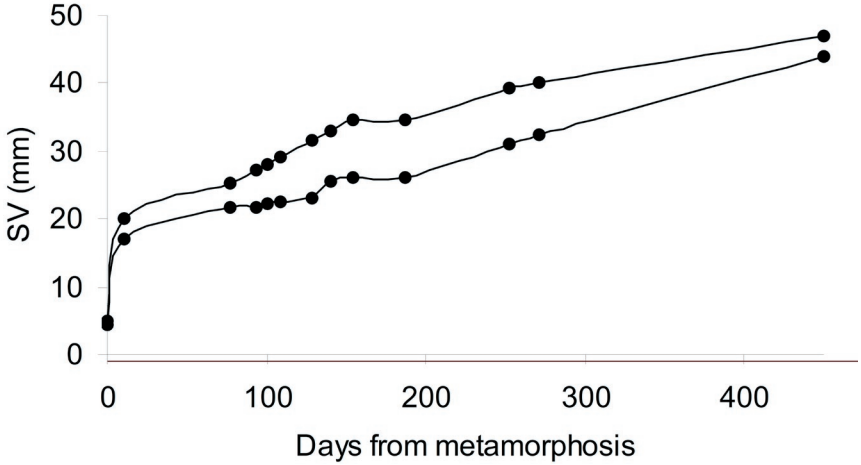

Fig. 4. Growth pattern of the first two tadpoles to reach metamorphosis.

15.6- 19.5mm. Metamorphs climbed up the sides of the glass aquarium or onto rocks within 12 hours of developing hind legs. Once at least 3cm above the water line they remained largely inactive until the tail had been resorbed (2-4 days).

Discussion

Tachycnemis seychellensis tadpoles have been well described previously (Drewes 1984), and measurements were given by Boulenger (1882) who described an 18mm tadpole with at 44mm tail (probably transposed) and McDairmid & Altig (1999)

who gave a total length of 44mm. It appears that the latter two measurements refer to the same data, but the source of any of these specimens is not known. The present study supports previous descriptions with a body length of approximately 12mm and a total length of up to 44mm.

Previous accounts of reproduction in the Seychelles tree frog have provided little background detail and it is difficult to determine what is taken from direct observation or extrapolated from other species. From the present observations reproduction in this species can be summarised. Eggs may be laid more than once a year and are laid in clumps of approximately 150 eggs above the water. In addition to eggs laid above water as observed here, Nussbaum (1984) described eggs being "occasionally placed on the ground in shallow depressions, in dry stream beds, or beside a flowing stream" and speculated that these eggs were laid in anticipation of flooding. Whether this is a deliberate strategy or the result of laying in inappropriate sites remains unknown and further field research is required to clarify this point. Henkel & Schmidt (2000) reported eggs laid in the water, which does not fit with the present observation of those of Nussbaum (1984). Embryonic development and hatching occurs out of water, and the fully developed tadpoles fall into the water below the egg mass.

Development of *Tachycnemis* tadpoles is extremely variable within clutches, time from hatching to metamorphosis varying from 45 to 141 days. In both clutches of eggs it appears that most tadpoles can be divided into fast or slow growing categories, with a clear bimodal distribution of metamorphosis dates. The second clutch developed more slowly and has a less pronounced bimodal distribution. This may be due to them being placed with the slow developing cohort of the first clutch, thus effectively subjecting this group to high levels of competition and slowing the early stages of development. The presence of two developmental strategies within egg clutches may

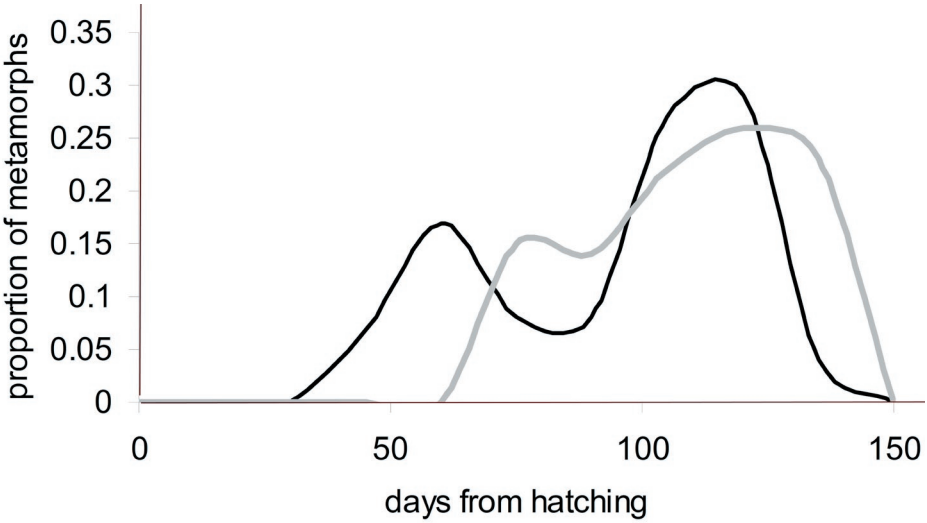

Fig. 5. Metamorphosis rates of the two captive-bred clutches of eggs. Black line – July clutch. Grey line – October clutch.

mean that most tadpoles spend an extended period of time feeding in water and reaching a maximum size for metamorphosis whilst others develop rapidly, ensuring that some metamorphs are produced even in ephemeral water bodies. No difference was observed between fast and slow developing tadpoles in size at metamorphosis. Tadpoles fed on detritus, especially old decaying leaves.

For the fastest growing individuals age to maturity (as indicated by male calling) was 450 days from metamorphosis (or 485 days from hatching). This was the earliest calling recorded and is not necessarily the same as true sexual maturity, but gives some indication of the development rate of the species. This calling male was 44mm SVL. This rate of development appears to be similar to many other tree frog species, although there are very few quantified studies. For example, the spotted tree frog *Litoria spenceri* is reported to mature at 3-4 years of age (NSWNP & WS 2001) whilst the Pacific tree frog *Pseudacris regilla* matures in 3-4 months (Jameson 1956).

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Phelsuma **18** (2010); 90-94

A short note on the Striped Policeman Butterfly, *Coeliades forestan* (Lepidoptera: Hesperiidae) in Seychelles

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Introduction

The Striped Policeman (*Coeliades* forestan (Stoll, 1784)) is the largest skipper (forewing length approximately 22mm) found in Seychelles. It is easily recognised by a very prominent white stripe across the ventral surface of the hindwing (Bowler 2006). It shows a great deal of ecological adaptability, and may be found from dense rain forests through to unnatural grasslands (Larsen, 1996; Lees, *et al.,* 2003). Although it may be numerous in a given locality, more often than not, single specimens can practically turn up anywhere (Larsen 2005).

In a recent revision of the subfamily Coeliadinae (Lepidoptera: Hesperiidae), Chiba (2009) recognised 9 genera, 78 species and 202 subspecies. The genus *Coeliades* consists of 13 species and 19 subspecies. Two subspecies of *C. forestan* are recognised, the nominate subspecies *C. forestan forestan* (Stoll, 1784), and the Madagascan subspecies *C. forestan arbogastes* (Guenée, 1862). *C. forestan arbogastes* differs from the nominate subspecies by having the basal area of the hindwing, and dorsal surface of the thorax, overlaid with blue-green rather than beige scaling. This gives *arbogastes* a very different characteristic appearance compared with the nominate subspecies (Fig 1a). All historical records of the Striped Policeman in Seychelles have been of the Madagascan subspecies *arbogastes*.

However, during a recent trip to the Natural History Museum (NHM), London (February/March 2010), various specimens of the nominate subspecies *C. forestan forestan* from the main granitic Seychelles island of Mahé were found. This is in contrast with the published literature, which only lists *arbogastes* from Seychelles. As a result, this short article aims to discuss: 1) the distribution of the two *C. forestan* subspecies; 2) all Seychelles historical published records of *C. forestan*, and; 3) which subspecies of *C. forestan* occur in Seychelles. Furthermore, there is very little information on the species from any Seychelles islands. It is hoped that this article will promote further interest in this species, and that further distributional records will made.

Distribution of *Coeliades forestan*

The nominate subspecies *C. forestan forestan* is widely distributed throughout Africa (Ackery *et al.* 1995), including the Indian Ocean islands of Mauritius (Davis & Barnes 1991), Comoros (Grand Comoro, Anjouan and Moheli) (Turlin 1995) and Réunion (Maitre & Rochet 2008).

The other subspecies, *C. forestan arbogastes* occurs on Madagascar (Viette, 1956), and has historically been recorded from Seychelles (Gerlach & Matyot, 2006). Turlin (1995) believes that *arbogastes* may occur on the island of Mayotte, Comoros.

The type locality of *arbogastes* was given, in error, as Réunion, which may have created some confusion about its actual distribution. As a result, *arbogastes* has, incorrectly, been recorded from Réunion by Legrand (1965) and Cogan (1984), and from Mauritius by A.E. Williams (2006) and J.R. Williams (2007).

Historical records of *Coeliades forestan* in Seychelles

The first record of *C. forestan* from Seychelles was by de Joannis (1894), on Mahé (as *Ismeme arbogastes*). A single *C. forestan* specimen was collected on Mahé, Cascade Estate, 800' a.s.l., 2 November 1905 (as *Rhopalocampta arbogastes*) (Fletcher 1910). Fryer (1912) believed that the species was probably not resident in Seychelles and that the *arbogastes* specimens from Mahé probably represented stragglers. Legrand (1965) (as *Coeliades forestan arbogastes*) records a further three specimens from Coëtivy (1959), and a single specimen from La Digue (1960). The only Seychelles island that *C. forestan* has been regularly recorded from is Aride (1987-89; 1998-2005) (Bullock 1989; Carty & Carty 1996; Bowler & Hunter 1999, 2000; Gerlach & Matyot 2006). Clearly, all historical records of *C. forestan* in Seychelles indicate that the specimens belong to the Madagascan subspecies *arbogastes*.

Seychelles specimens of *Coeliades forestan* in the Natural History Museum, London

A total of seven *C. forestan* specimens collected from Seychelles were examined in NHM. These included two specimens from Cosmoledo (both collected by P.R. Dupont), and five specimens from Mahé (four collected by J.A. de Gaye in 1906 and 1907; and one collected T.B. Fletcher in 1905).

The two specimens from Cosmoledo were the Madagascan subspecies *C. forestan arbogastes* (Fig. 1b). Cosmoledo forms part of the Aldabra group of islands and lies 360 km NW of the northern tip of Madagascar, and 560 km SW of Mahé. The Aldabra Islands have been considered part of the Seychelles since 1881, except for a brief period between 1965 and 1976 when they formed part of the British Indian Ocean Territory (Lionnet, 1995).

All the Mahé specimens were the nominate subspecies *C. forestan forestan*. The Fletcher specimen examined in the NHM [BMNH(E)#895138] is clearly that of the nominate subspecies (Fig. 1c), and not *arbogastes* as listed in his 1910 paper. Mahé lies approximately 1140 km NE off the northern part of Madagascar and about 1600 km E off the African east coast (Tingay 1995). Furthermore, specimens collected on Mahé (2002) and Cousine Island (2009) (a new Seychelles locality record for this species) by the author were the nominate subspecies, and not *C. forestan arbogastes*.

Discussion

Both subspecies of *C. forestan* have been recorded from Seychelles. The limited evidence suggests that the nominate subspecies *C. forestan forestan* does occur in the granitic islands, and the Madagascan subspecies, *C. forestan arbogastes*, has been recorded from the southern Aldabra island group. No evidence has, so far, been found to indicate that the Madagascan subspecies *arbogastes* occurs in the granitic Seychelles

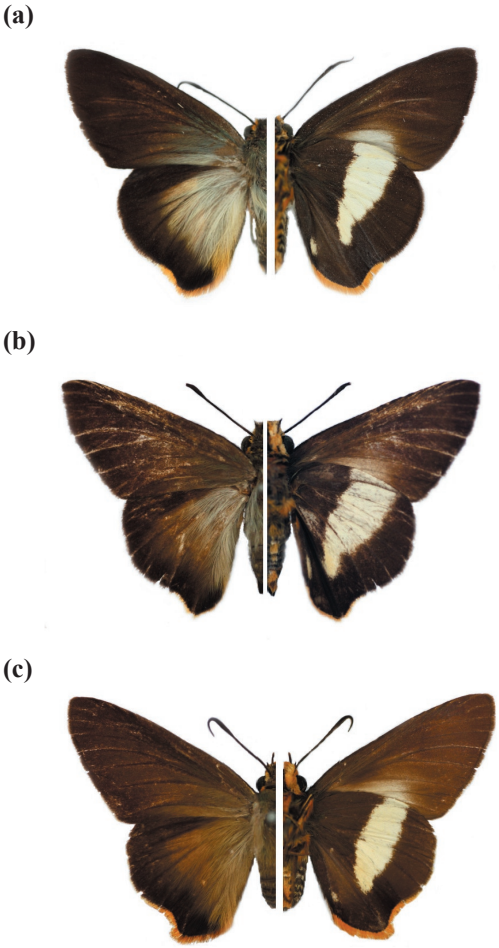

Fig. 1. *Coeliades forestan* (dorsal surface on left; ventral surface on right): **(a)** *Coeliades forestan arbogastes* [MADAGASCAR]; **(b)** *Coeliades forestan arbogastes* (worn specimen) [COSMOLEDO, SEYCHELLES; P.R. Dupont; BMNH(E)#895136]; **(c)** *Coeliades forestan forestan* [MAHÉ, SEYCHELLES; T.B. Fletcher; BMNH(E)#895138]

islands. There may possibly be granitic Seychelles island *arbogastes* material in collections other than that of the NHM.

The occurrence of *C. forestan arbogastes* on Cosmoledo is understandable given its close proximity to Madagascar. It appears that *arbogastes* is confined to Madagascar and at least one of the adjacent islands (i.e. Cosmoledo), even though Cosmoledo falls under the political control of Seychelles. *Coeliades forestan arbogastes* appears to be quite widespread on Madagascar (Viette 1956). Furthermore, SE winds with easterly

jet streams between June and October are the predominant winds in the Aldabra region (Shah 1994), which may further assist dispersal from Madagascar. Although *C. forestan* does not migrate regularly, there is some evidence to indicate that it has some migratory capacity (Larsen, unpubl.), which may further account for the Cosmoledo records.

To summarise, both subspecies of *C. forestan* have been recorded from the Seychelles islands. To draw conclusions about the distribution of each subspecies in Seychelles is very difficult at present, given the scarcity of records. Additional records are required to determine the distribution and resident status of the two subspecies in Seychelles. The author would greatly appreciate any further information, records or specimens of *C. forestan* from any Seychelles islands, and may be contacted via the above address.

Acknowledgements

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On a new Coccinellidae for Seychelles

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In 2009 a new ladybird (Cocinellidae; Coleoptera) for Seychelles was collected in a malaise trap at Jardin Marron on Silhouette island. This has been identified as *Platynaspis capicola* Crotch, 1874. This ladybird is black with pronotal angles yellowish and with two red spots on each elytron, posterior spot smaller than anterior. The dorsum is finely pubescent. Total length is 2.7mm. The species has previously been recorded from Africa, Madagascar and the Mascarenes. In addition to this specimen the same sample (August 2009) also included one specimen of *Scymnus oblongosignatus*. At the same time *Vedalia cardinalis* and *Chilomenes sexmaculata* were collected in a malaise trap at Mon Plaisir.

Platynaspis capicola is a predator of the soft-brown scale *Coccus hesperidum* Linnaeus and Aphididae *Aphis gossypii* Glover.

Phelsuma **18** (2010); 96-97

On the first sinistral land-snail recorded in the Seychelles islands

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In July 2010 a sinistral specimen of the snail *Priodiscus serratus* (Adams, 1868) was collected on Mon Plaisir, Silhouette island (Fig. 1). This small member of the carnivorous family Streptaxidae (Pulmonata) is locally abundant at above 500m above sea level and is believed to be a predator of small soft-bodied invertebrates, such as nematodes and very small snails. Although sinistrality is common in some snail faunas this is the first record from the Seychelles islands. 65 specimens of this species have been examined (giving a sinistrality frequency of 1.5%) and over 3,250 land snail specimens from the islands (0.03% sinistral).

Some snail species may be entirely sinistral (mainly in the families Achatinidae, Bradybaenidae, Buliminidae, Camaenidae, Chondrinidae, Helicidae, Helixarionidae, and Vertiginidae). The arboreal families Achatinellidae, Orthalicidae and Partulidae have the highest frequency of sinistral species, and may also have some species with mixed chirality. The appearance of chirality mutant may create barriers to gene flow (Davidson *et al.* 2005) as normally snails mate in a head-to-head position, allowing alignment of the genitalia on the right side of the body. Courtship between sinistral and dextral snails would not allow alignment of genitalia. It seems that this is more of a problem for low-spired species as high-spired forms may not be restricted to the head-to-head position (Asami *et al.* 1998).

There have been no comprehensive surveys of the frequency of chirality mutants in recent snails. A study of it frequency in Quaternary fossils found that most species and sites showed extremely low frequencies of mutants (much lower than 1%) from all strata and the few reversed forms found persisted for a shorter span of geological time than the normal forms. One species showed a frequency of 10% and to have lasted for some 6,000 years at this level (Preece & White 2008).

In the Western Indian Ocean sinistral shells have been found in Madagascar (*Helicophanta gloriosa*) and in Mauritius in *Achatina fulica* and *A. immaculata* (rarely in both) and one specimen of *Gonospira modiola*, this is the only sinistral Streptaxidae out of more than 2000 examined (O. Griffiths & V. Florens, pers. comm.). Two genera are normally or frequently sinistral in Madagascar (*Fauxulus* spp and *Nesopupa minutalis*) (O. Griffiths pers. comm.).

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Fig. 1. Sinistral (left) and dextral (right) individuals of *Priodiscus serratus* collected within 1m of each other at Mon Plaisir, Silhouette.

The rare Ghost Duskdarter dragonfly *Zyxomma petiolatum* on Desroches Island, Seychelles

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On each evening at dusk, between 11th and 21st April 2010, the rare Ghost Duskdarter *Zyxomma petiolatum* was hawking the northern shoreline of coralline Desroches Island, Amirantes, Seychelles. It also attempted to lay eggs in swimming pools. What is surprising is that this sandy island is virtually waterless, with only a small pool for tortoises. These dragonfly individuals may have come from the granitic Seychelles, where it has been recorded (Bowler 2006). However, its rarity there, and in Asia (Bedjanič *et al.* 2007), does not make it a normal candidate for migratory behaviour, suggesting that there is also a chance that it might be breeding in very small semi-permanent pools on Desroches Island.

The only other odonate recorded on Desroches at the same time, was the Voyaging glider, *Tramea limbata*, a well-known long-distance migrant.

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Protecting hatchling turtles from light pollution

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Tourism developments close to or directly facing turtle nesting beaches very often cause light pollution that can disorientate turtle hatchlings as they emerge from their nests. On the island of Silhouette (Seychelles) the Environmental Impact Assessment for a major new hotel development highlighted the importance of protecting the turtle nesting beach. To this end, great care was taken to maintain and to increase the beach-crest vegetation. Requests to change the external lighting on rooms situated immediately behind the beach crest led to minor but wholly inadequate modification to shades over the lamps.

The first turtle nesting season after the opening of the hotel proved how inadequate these measures were. Some 200 hatchling hawksbill turtles (*Eretmochelys imbricata*) were rescued from under and around the hotel buildings. These were released on an unlit area of the same beach about 1,000 meters to the south-east.

Prior to the next turtle nesting season discussions were held with the hotel management and a decision was taken to try a novel solution to the problem of hatchling disorientation. This led to the construction by the hotel maintenance staff of a large box to be placed over the nest in order to obscure the hotel lighting.

Turtle box construction

The box was made as large as possible, having the dimensions shown in Fig. 1. Waterproof plywood was used and the interior of the box was painted matt black. On the exterior of the box a large sign was painted to inform visitors to the hotel of the presence of the nest. Once the boxes have been made, they can be stored for future use.

Turtle nests are monitored by the hotel staff and are marked with a sign to prevent visitors walking on the nests. At 50 days after the eggs are laid, the light excluding box is placed over the nest site. The nest is covered by the back section of the box and the open end of the box faces the sea, allowing the hatchlings to start their journey to the sea in total darkness and to move down the seaward slope of the beach without seeing the lights.

Discussion

Protecting turtle nesting beaches where tourism development has been allowed requires cooperation between conservationists and hotel management and staff. The presence of nesting turtles and an indication that the hotel is involved in their protection will enhance visitor experience, benefitting the tourism development and, most importantly, will help to protect the turtles.

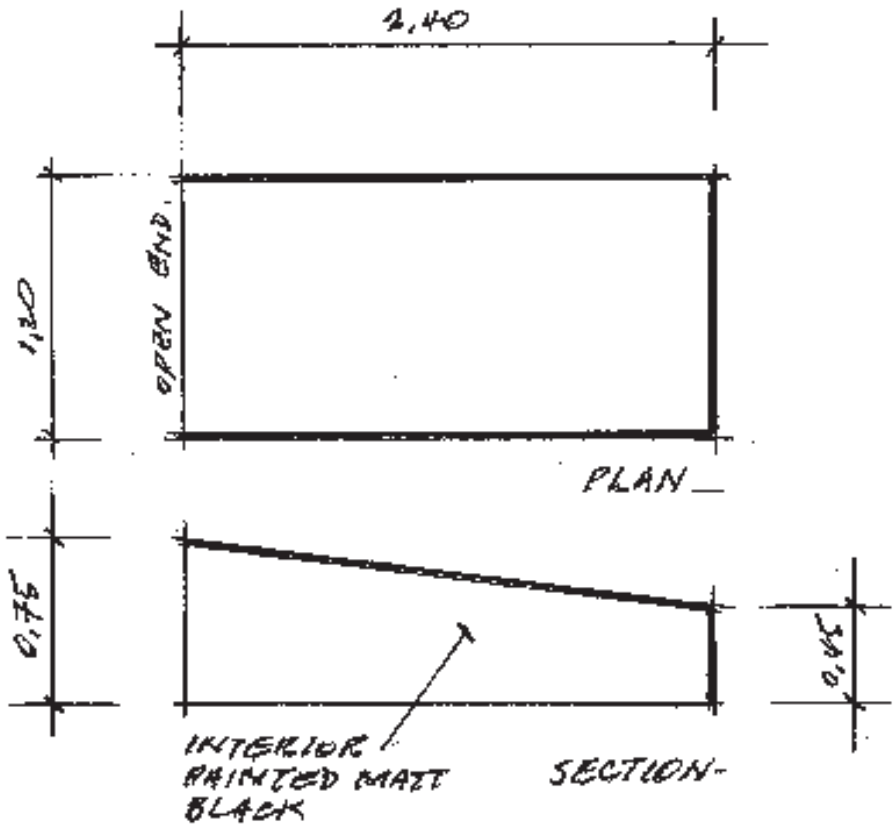

Fig. 1. Dimensions of the turtle box. Measurements in meters.

At the time of writing this note, the light excluding boxes have been used during two turtle nesting seasons. In 2008-9 only three hatchings were rescued from the hotel grounds. In 2009-10 two hatchlings were rescued from the hotel lake and one more found on the road at the far end of the beach, away from the hotel rooms. This indicates that the light excluding box is effective in reducing hatchling disorientation. It is a reasonably low-cost solution for the protection of turtle hatchlings and requires only a basic level of carpentry skills.

Fig. 2. Turtle box in situ